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ABSTRACT

THIS STUDY COLLECTED AND INTERPRETED FACTS ON THE NEED FOR, USE OF, AND APPRAISAL OF, PROFESSIONAL CONTINUING EDUCATION (PCE) BY RESEARCH AND DEVELOPMENT SCIENTISTS AND ENGINEERS IN THE FEDERAL GOVERNMENT AND INDUSTRY. THERE WERE THREE BROAD APPROACHES: INTERACTION MODES (INCLUDING PROFESSIONAL MEETINGS, SEMINARS, LECTURES, AND SABBATICAL LEAVES); SUBSIDIZED SHORT COURSES AND OTHER NONCREDIT AND CREDIT OUTSIDE COURSES; JOURNAL CLUBS AND OTHER EDUCATIONAL ACTIVITIES IN THE LABORATORY. TOP MANAGEMENT PROVIDED SOME EDUCATIONAL OPPORTUNITIES, BUT MOTIVATION WAS LARGELY RELEGATED TO SUPERVISORS. ACTUAL EMPLOYER PROGRAMS CONSISTED MAINLY OF COMBINATIONS OF UNIVERSITY CREDIT COURSES, PROFESSIONAL MEETINGS, AND LABORATORY LECTURES AND SEMINARS. PARTICIPANTS SAW PCE AS A COMPLEX AND DYNAMIC PROCESS ORIENTED TOWARD KEEPING UP TO DATE WITHIN ONE'S OWN DOMAIN OR RELATED DISCIPLINES, OR ACQUIRING ADDITIONAL PERTINENT INFORMATION NEEDED TO CONTINUE IN ONE'S AREA OF SPECIALIZATION OR ASSIGNMENT. IN THE UNIVERSITIES, RESEARCH AND DEGREE TEACHING WERE OF HIGHER PRIORITY THAN PCE. RECOMMENDATIONS WERE MADE FOR ACTION BY MANAGEMENT, PROFESSIONAL SOCIETIES, AND UNIVERSITIES. (INCLUDED ARE A BIBLIOGRAPHY, LIST OF COOPERATING INSTITUTIONS, AND 29 TABLES.) (LY)

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CONTINUING EDUCATION FOR R&D CAREERS

An Exploratory Study of Employer-Sponsored and Self-Teaching Models of Continuing Education in Large Industrial and Federal Government Owned R&D Laboratories

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by the
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We also wish to acknowledge the assistance of the many people who took the time to correspond with us, and make suggestions and recommendations. The literature on continuing education is scattered throughout a great variety of publications, and much of it is not formally published. Our correspondents gave us valuable direction in collecting this literature and even supplied much of it. The bibliography lists not only items cited in the text, but additional items of interest and relevance to this study.

Finally, deep appreciation is expressed for the time and assistance given to Social Research, Inc. by the laboratories, universities and colleges, and the members of their staffs who participated in this study. The participating laboratories and universities and colleges are listed in Appendix B.

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PREFACE

This report is directed to employers, universities, professional societies, scientists and engineers, and all others concerned with the problems of maintaining the quality of the professional work force of the United States. The exponential growth of science and technology during the past two decades has generated demands for comparable growth on the part of scientists and engineers. Thus, their effective utilization is highly important. At the same time, technological obsolescence progressively reduces their effectiveness unless steps are taken both by themselves and by those who employ them. The critical nature of the problems of obsolescence has stimulated a variety of corrective efforts commonly called "continuing education." For obvious reasons, a high degree of concern about technological obsolescence centers in the R&D laboratory.

The literature on continuing education implies the existence of considerable activity addressed to enriching subject-matter resources and improving communication mechanisms so as to bring professionals, and engineers in particular, into contact with new knowledges and technologies. There is a scarcity of information on scientists in general and on both scientists and engineers in R&D, the presumed source of much new knowledge and of developments of significance to national life. In addition, the literature leaves unanswered many questions to which it would be helpful to have answers, even if these can be only tentatively stated. In a purely exploratory way, this study undertakes to examine some of the dynamics of the continuing education process in the context of R&D types of work.

The study was initiated on May 15, 1966. The pilot study of one laboratory was undertaken in September. Data were collected from 16 other laboratories during the months of January through September of 1967.

During this time, there was considerable discussion in the literature and among scientists and engineers about continuing education issues raised in the Joint Advisory Committee report on Continuing Engineering Studies and the Interim Report of the "Goals" Committee on Engineering Education. These two documents have had considerable influence on how people think and talk about continuing education. The former, the JAC report, was available at the time this study was planned, and it was used as a starting point. The Goals Committee Report became available during the course of this study and also has been of value to us. We begin with these two documents in our review of the literature in Chapter I.

This is an exploratory study and as such raises more questions than it answers. In the data-gathering process, we have concentrated our attention on the research scientists and engineers and on their 17 employers. We have collected only limited data from university representatives and no systematic data at all from professional societies. The purpose and scope of the study are elaborated in Chapter II. The remaining chapters are devoted to an examination of specific issues and concerns outlined there. A summary and a list of the recommendations scattered throughout the report are given in the final chapter.

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CHAPTER I

CONTINUING EDUCATION -- CONCEPT AND BACKGROUND

Continuing education is still emerging and crystallizing as an area of special concern for those scientific and engineering disciplines and activities marked by dramatic and unremitting advances, modifications, and innovations stemming from new knowledge and new technologies.

Definition and Scope of Continuing Education

In the past three to five years, the literature shows an increasing tendency to define continuing education rigorously in terms of precisely conceived objectives. It is increasingly common to distinguish between advanced education and continuing education, even though the two are frequently intertwined. The Interim Report of the Committee on Goals of Engineering Education of the American Society for Engineering Education (known popularly as the Goals Committee) lists four objectives of engineering education beyond the first basic degree. The report further indicates that the first of these objectives refers to advanced education -- beyond the bachelor's degree -- and the remaining three to continuing education. For general descriptive purposes, this report uses their categories, which are as follows:[1]

> 1. Upgrading a person's education (a person may work toward a graduate degree to raise the level of his formal capabilities).
>
> 2. Updating a person's education (a person who received a BS degree 10 years ago may wish to take course work to make his formal education comparable to that of a person receiving a BS degree this year).
>
> 3. Diversification to new fields (a person educated in one field may seek to obtain some formal education in another field, but not necessarily at a higher degree level).

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[1] Interim Report of the "Goals" Committee. Lafayette: Committee on Goals of Engineering Education, American Society for Engineering Education, Purdue University, April, 1967, p. 41. (In this quotation, italics are ours.)

> 4. Maturing of a person's education (a person may add a new perspective in his own field, such as the inclusion of financial, temporal, political, and social factors).

The Committee also notes one other important characteristic of continuing education studies, that they usually refer to training which better equips a person for his contemporary work, for the job he has now or aspires to in the near future.[2] Thus, continuing education emphasizes practicality and immediacy, in contrast to basic professional education and to upgrading or the pursuit of advanced degrees in traditional ways. The Joint Advisory Committee (JAC) defined its task as follows:[3]

> At the outset, the objective of "continuing engineering studies" was recognized as the specific enhancement of the competence of the individual as a practicing engineer, rather than the attainment of an additional academic degree. In turn, this objective required a process of enhancement so planned as to keep the individual abreast of both advances in the underlying basic sciences, and the evolving technical applications and methods of enhancement including courses, seminars, conferences, institutes, and related diversity needed to match the wide range of backgrounds that the participating individuals might possess.

Both these reports maintain the distinction between advanced degree-seeking education and continuing education; this same distinction is made in the present study.

This classification excludes the student who progresses from his basic education through advanced education to the graduate degrees without prolonged interruption. But what about the experienced professional who has worked one or more years and then seeks a degree either part-time or full-time during a leave of absence? Or what about the student who finishes his basic education and goes immediately into an employer program of part-time work/part-time study for an advanced degree? In this study, these also are excluded from the purview of continuing education.

---

[2] See also, Samuel S. Dubin and H. LeRoy Marlow, Continuing Professional Education for Engineers in Pennsylvania. University Park: The Pennsylvania State University, 1965, p. 17, which quotes Ingersoll: "Continuing education shall be defined as that education which is needed by the professionally employed engineer as perceived by him or his employer to enhance his total job competence."

[3] Continuing Engineering Studies: A Report of the Joint Advisory Committee. New York: Engineers Council for Professional Development and others, 1965, p. 11.

In practice, however, there is still some choice involved. Clearly, many people do regard themselves as involved in continuing education when they are taking university credit courses for a degree, and the literature sometimes fails to distinguish among the purposes delineated by the Goals Committee -- that is, to distinguish updating, diversification, and maturing from upgrading. For example, the Professional Engineers in Industry (known as PEI) report that:[4]

> Of the 1,412 respondents who participated in any type of continuing education in the five-year period 1960 to 1965, 444 received 12,988 college credits for an average of 21 [sic] credits per man. ...Close to 70% of these credits were earned by engineers employed in the fields of manufacturing, research and development, and government (federal, state and local).

Of these 1,412 persons, 67 percent took technical courses, 39 percent took managerial courses, and 22 percent took "personal development" courses unrelated to either of the foregoing.

Since management training for scientists and engineers represents a shift out of the technical career line, most writers exclude it from continuing education. While such training could easily be taken as one kind of "diversification" in the Goals Committee sense, it is neither a refreshment nor a continuation of the technical-scientific education of these specialists. It may be both necessary and useful to them as supervisors and managers, but it does not relate to technological updating or diversification. Working engineers and scientists often become aware of deficiencies in their management and communications skills. As a result, such skills are mentioned frequently in surveys, such as the PEI one just cited, which lists course work engineers say they need, want, or would take if it were available. Probably, such studies are sometimes best categorized as diversification, sometimes as maturing under the Goals Committee's schema.

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[4] Continuing Education of Professional Engineers, A PEI Survey Report. Washington: National Society of Professional Engineers, 1966, pp. 21 and 23.

The Goals Committee schema does not specifically list the "refresher" objective of continuing education, that is, the review of once-familiar material to enhance skill and competence in present-day use and application. Logically, this is distinct from updating, which means the acquisition of new knowledge developed since the last period of formal education. Throughout this report, reference to "refresher" activities or objectives covers restudying once-familiar material in order to make contemporary use of it, as distinct from updating, or studying material not available at the time of formal education.

In this study, the definitions given above are followed. Management training, "maturing," and degree-seeking studies are specifically excluded. The report refers to refreshing, updating, and diversification activities in engineering and scientific fields of study. However, information was collected on employer-sponsored degree-seeking programs, since employers consider these significant in their educational efforts. The data on degree-seeking programs are summarized in Chapter III, "Employer Policy and Practice."

The intertwining of continuing education with the acquisition of management and communication skills can be seen as stemming from the ongoing duties of many professional positions (and to the normal higher or supervisory levels of career line). However, the intertwining of continuing education with advanced degree-seeking studies reflects another phenomenon, that is, technological obsolescence among scientists and engineers stemming from accelerated growth and expanding horizons of technology and knowledge. In order to maintain their job effectiveness, working scientists and engineers must recurrently acquire new knowledge synthesized since their last degree. Their degrees are in part obsolescent because the knowledge represented by the degree is itself partly obsolescent.

Expanding knowledge is one important source of obsolescence, but there are others as well. People may go stale because of work pressures, specialization, and lack of opportunity to use certain skills. They need refreshing to sharpen up the skills and knowledge they once had. Such obsolescence can be seen when individuals change assignments and find it necessary to do some concentrated refreshing and catching up in fields in which they are expected to be competent. The activities undertaken to overcome obsolescence, whatever its source, are properly construed as continuing education. Technological obsolescence is a central concern of continuing education.

Technological Obsolescence

A substantial segment of the literature uses the term "technological obsolescence." Sometimes undefined, technological obsolescence in an individual is generally taken to mean a deficiency of knowledge such that he approaches problems with viewpoints, theories, and techniques less effective than others currently used in his field of specialization. Several types of obsolescent person are readily identified. One is the man who has not kept up with new knowledge and techniques in his field. His professional competence ages in the face of scientific and technological growth, and makes him obsolescent as compared both to new graduates and to his colleagues who keep up and who apply new findings. A second type is the individual who keeps up with a very narrow segment of his field (usually by working in it for years), but who loses contact with broader changes. This second person is so "overspecialized" that he cannot effectively undertake new work in his own or in closely related fields, and cannot apply relevant new knowledge from them to his own particular specialty. A third type is the person whose career line evolves from one interest to another, so that he moves away from his original field of training into another not very closely related one. He is obsolescent in his own specialty because his training is no longer closely integrated with his work. It is often more logical than meaningful to classify such a person as obsolescent.

Obsolescence is not an all-or-nothing proposition. It is a process, and it is relative. Degree of obsolescence must always be a function of new knowledge and new techniques. Many fields of science and engineering are changing rapidly with the discovery of new facts, theories, viewpoints, and techniques; the rates of change vary both among fields and among their sub-specialties. There is also the important matter of which new development or new technique is relevant to a particular person's work -- not all changes affect all persons, and the impact varies in kind and degree for all those who are affected. For example, a wide range of scientists and engineers in research have recognized a need to understand and use the output of NMR (nuclear magnetic resonance spectroscopy), but fewer have felt the need to learn to operate the equipment necessary to produce the output. Another example is the revolution in the field of seismology in the 1950's. As reported by a seismologist in our sample, all seismologists had either to change their thinking and update their training or accept the alternative of becoming obsolescent within a very few years.

Although obsolescence does not affect all people in the same way or to the same degree, a majority of people clearly recognize it as a threat or potential threat to their continued productivity and/or employability. There is clear evidence that the nature of the felt threat varies. Several studies in the literature show that engineers indicate a need for education in technical subjects (in addition to the managerial and communication skills mentioned earlier). One survey[5] contrasts engineers holding only a bachelor's degree with those who have advanced degrees. Those with advanced degrees select significantly more technical and non-technical subjects, showing that their felt need for continuing education is greater than that of those with bachelors' degrees only. With reference to content, the survey cited above states that subject areas associated with mathematics were more frequently reported as needed than other subject areas. In addition, research engineers selected more technical subjects, especially mathematical ones, than did engineers working in other functional job categories. Dubin and Marlow report similar findings for the Pennsylvania engineers.[6]

A different approach to felt threats of obsolescence is seen in an opinion-poll survey designed to assess the degree of felt obsolescence.[7]

> Keeping up with technological development is a problem to nearly all (89%) of the 931 scientists and engineers responding to the April "Opinion Poll" on technological obsolescence.
>
> For more than half the respondents [56%], the problem occurs moderately often; but for 36%, it is a serious difficulty. Two

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[5] Education in Industry: A Study by the Joint ECAC-RWI Feedback Committee. Washington: American Society for Engineering Education, 1965.

[6] Samuel S. Dubin and H. LeRoy Marlow, Continuing Professional Education for Engineers in Pennsylvania (previously cited).

[7] "Eighty-Nine Percent of Scientists and Engineers Face 'Technical Obsolescence'." Industrial Research (July, 1967), p. 15.

> out of three respondents often have assignments that require some quick "boning up" because they are not aware of recent developments. Another 20% face this situation very frequently.
>
> By job function, survey participants fell into the following categories: scientists, 45%; engineers, 35%; managers, 18%; and technicians, 2%.

The results of this poll are relevant to the present research because they support the finding that scientists, too, face technological obsolescence, just as engineers do. In addition, these figures, while admittedly based on a self-selected sample, indicate that the majority of scientists and engineers (in this group of 931) recognize they have a problem of keeping up to date, and that this problem is one of degree as well as of recurrence. This poll also implies that there is considerable difference between a "quick boning up" and a need to restudy academic course content in depth as a result of new knowledge and new techniques. (See also Chapters V-VII of this report.)

Other studies deal with the employability of those who do and those who do not keep themselves up to date. One rather remarkable finding derives from an examination of the background of 125 engineers all laid off at one time by a large division of a major corporation.[8]

> ...Among the numerous variables...noted was that the salary range was from $8,000 to $18,000, that the lengths of service were from two to 20 years, that the engineers came from a wide variety of institutions and had a wide variety of experience. However, [there was] one interesting constant among all -- not one had taken any form of extracurricular education in the past six years.

Whatever the reason the employer had for this mass layoff, the implication is clear that those who are inactive in "extracurricular education" are those most likely to become unemployed. The relationship between obsolescence and unemployment time after layoff has also been investigated in another study of 250 laid-off engineers in the Greater Boston area.[9]

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[8] Benjamin G. Davis and Erhardt C. Koerper, "Catch On and Catch Up." Mechanical Engineering (August, 1965), pp. not given on our reprint. These authors are members of the AIME Committee on Continuing Education. They are reporting an apparently unpublished study to which they had access and for which they give no reference. Other circumstances are not reported, such as whether or not reading the literature and other self-teaching efforts are part of "extracurricular education."

> ...Engineers who were currently studying for higher degrees, and thus making an effort to stave off obsolescence, had substantially less time between layoff and re-employment than the other men in their age brackets.

Other professionals face problems of obsolescence also, as the continuing education programs of the American Medical, Dental, and Bar Associations testify. (In fact, the American Medical Association program has been cited by some authors as the one the engineering societies should seek to emulate.)

What has been said so far about technological obsolescence has assumed a context of "overcoming" individual obsolescence, and indeed much of the literature has this orientation. However, in addition to the technological obsolescence of an individual who fails to use the latest knowledge and techniques in his field, there is also emphasis on obsolescence of knowledge and techniques themselves. For example, a few years ago an often-encountered saying cited "the vacuum tube specialist in an era of transistors." The transistors referred to were soon supplanted by smaller transistors, and now applications of solid-state physics to printed circuits are sometimes supplanting small transistors. The use of superconductive materials may soon bring about still another instance of obsolescence in some of these technologies. This view of technological obsolescence emphasizes the changes taking place in knowledge itself as a source of the problems experienced by individuals, rather than stressing inaction on the part of individual professionals.

Changes in knowledge may take place quickly and have abrupt, far-reaching implications for a field, or they may evolve slowly over a period of time and only gradually affect practitioners. In the first instance, the changes create simultaneous obsolescence in substantial numbers of people working in the field or fields affected by the changes. Because sudden changes are dramatic, it is more difficult for people to overlook or ignore the fact that they, as individuals, are obsolescent until they catch up with the new.[10] On the other hand, when changes evolve slowly, it is entirely possible for people who are only incidentally or marginally affected at any time to overlook their increasing obsolescence and to put off the usually strenous efforts needed to retrain themselves.

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[9] Quoted in Personnel (Sept.-Oct., 1966), p. 5, in a review of Joseph D. Mooney of Princeton University writing in the July, 1966 issue of Industrial and Labor Relations Review.

Presumably, so long as the growth of scientific knowledge and new technology did not startingly challenge a professional's repertory of skills during the span of his career, technological obsolescence was commonly concomitant with aging; and continuing education was not an urgent matter. Widespread concern with technological obsolescence stems from the revolution in science and engineering -- particularly in their academic curricula -- which began during and after World War II, and came to a head with the dramatic accomplishment of Sputnik's launching and the furor subsequent to it. As Schoonover comments:[11]

> The launching of Sputnik I was acclaimed universally as a colossal feat of engineering. Immediately thereafter, the layman pointed an accusing finger at our engineers and demanded equal feats in the universe. The editorials and commentators made it appear as though our nation was caught napping.

In other words, powerful and emotional pressures from the society at large focused on an area of presumed technological obsolescence and demanded remedial action. In responding to the same issue, Kriegel notes that:[12]

> All of the educators contacted in the study feel that most SPE members educated 10 or more years ago need refresher training in varying amounts. The older system of education instilled an initial feeling of confidence by teaching the man where to find solutions for the problems existing in the industry at that time. Present curricula

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[10] The influence of such changes on motivation will be discussed later.

[11] Floyd E. Schoonover, "To Retread or Buy a New One -- That Is the Question." American Institute of Mechanical Engineering, June, 1966. (Mimeographed.) Mr. Schoonover, at time of writing, was chairman of Continuing Education Committee, AIME.

[12] Monroe W. Kriegel, "A Program for Improving the Technical Competence of SPE Members." Journal of Petroleum Technology (December, 1964), p. 1338.

> teach principally the fundamentals, and require that the man learn on the job how to apply them to specific problems. The recent graduate does not look for empirical solutions, but develops his own from his knowledge of scientific and engineering principles.

And the Joint Advisory Committee concluded:[13]

> There is now a significant difference between the preparation of recent engineering graduates and their counterparts of a decade or more ago. Large numbers of earlier graduates possess engineering experience which is no longer applicable and lack currently essential theoretical background. On the other hand, recent graduates possess much more sophistication technically, but still need instruction to be able to apply this knowledge effectively. For both of these groups, comprehensive systems of continuing engineering studies covering the spectrum from fundamental knowledge to engineering application are essential.

These changes are so pervasive and important that those individuals who did not keep up with them as they occurred face a major task of retraining.

Obviously keeping up to date is more arduous for an individual faced with sharp and far-reaching changes occurring abruptly than with changes which come about slowly and/or are restricted in scope. It is also obviously more demanding to keep up to date and proficient in several specialties than in only one or two. Yet the literature commonly implies that obsolescence is an all-or-none phenomenon, that the man who fails to keep up to date in a number of specialties or with his field in general will face sudden and drastic obsolescence when and if his knowledge and training are supplanted by new developments in his field. It was to guard against this that both the Goals Committee and the Joint Advisory Committee undertook to spell out the future needs of the engineers.[14] Planning the academic curricula and structuring the employment situation in such ways that engineers are trained and prepared for, as well as permitted to engage in, a lifetime of continuing study as part of their normal careers is one of the very current goals of the engineering profession. When this goal is achieved, "overcoming" obsolescence will give way to "preventing" obsolescence -- which is in turn synonomous with "keeping up to date" with new knowledge and maintaining useful skills and knowledges.

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[13] Continuing Engineering Studies (previously cited), p. 25.

[14] A similar effort is now in process in the mathematical sciences. See John Jewett and Clarence B. Lindquist, Aspects of Undergraduate Training in the Mathematical Sciences. Vol. I. Washington: Conference Board of the Mathematical Sciences, 1967. Volume II will deal with graduate education, and Volume III will deal with the role of mathematical scientists in industry and government.

As a footnote to this discussion we should like to point out that a comparable body of literature on scientists does not exist. Other than for chemists, we were able to collect very little literature on scientists and continuing education. (The continuing education activities of the American Chemical Society are both broad-range and continuous.) Nonetheless, on the basis of our own research findings, the problems in continuing education and combating technological obsolescence for research scientists do not appear radically different either in nature or degree from those of research engineers.

Implementing Continuing Education Activities

Out of the discussions and writings of the past few years, a practical consensus is emerging about the distribution of responsibilities in continuing education. The literature reflects stereotyped roles, assigned to the individual, his employer, his professional societies, and the universities. While the oversimplification involved will be immediately apparent, these roles should be considered here. Current thinking can be summarized as follows:

The individual carries the basic responsibility for his own development and for keeping up to date. His employer has the responsibilities of providing both opportunities for continuing education and a work environment-job structure climate that encourages him to keep up to date. The professional societies and universities are obligated to help him by providing educational opportunities and subject matters from which he can select those best fitting his needs. Employers and professional societies, more than universities, share some responsibility for making the man aware of his needs and helping him plan to meet them. The JAC, the Goals Committee, and the PEI reports, previously cited, all give explicit or implied recognition to a similar division of roles according to responsibility for combating technological obsolescence. Such "official" reports of authoritative bodies are one of the main ways of creating consensus on issues such as these.[15] The Federal Government also recognizes a distribution of responsibilities (here presented within the limits of the employee-management relationship):[16]

> In 1958, the Congress and the President ordered Federal managers to establish training programs. The Government Employees Training Act says: "it is necessary and desirable in the public interest that self-education, self-improvement, and self-training...be implemented by Government-sponsored programs." In short, the Act placed the basic responsibility for his own development on the initiative of the employee himself, and made all other training supplemental to his efforts. If he wants to learn, to advance. opportunities are at hand to help him. Once he is motivated to seek them out, he will get guidance from management.

Some industry spokesmen accept a somewhat larger share of the responsibility for continuing education:[17]

> In the past, it was commonly accepted that the employee has the entire responsibility for keeping himself up-to-date. Several factors are now causing important changes in this thinking, however. First of all, the problem of keeping up-to-date has increased by several orders of magnitude in the last two decades. Secondly, the increasing costs...to support a technical man supplies the company with a strong economic incentive... Then, too, employees are encouraged to plan an increasing role in community affairs, thus reducing the time available for continuing education.

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[15] There are numerous official statements about the educational role of specific professional societies. See also William A. Conwell, "Continuing Education -- What ASCE Is Doing." Civil Engineering -- ASCE (May, 1965), p. 32. Also Robert D. Forger, "The Role of SPE as an Educational Organization." Paper read before an Engineering Institute of the University of Wisconsin, Madison, May 25, 1966. (Mimeographed.) "SPE" refers to the Society of Plastics Engineers. Also, William M. Mueller, "The Role of the Technical Society in Continuing Engineering Studies." Paper read before the Annual Meeting of the American Society for Engineering Education, Washington State University, Pullman, June 20-24, 1966. (Mimeographed.) Mr. Mueller is director of education for the American Society of Metals.

[16] Investment for Tomorrow, A Report of The Presidential Task Force on Career Advancement. Washington: Government Printing Office, 1967, p. 12.

[17] Chalmer G. Kirkbride, "Industry's Stake in Post-College Professional Studies." Paper read before the Annual Meeting of the American Society for Engineering Education, Illinois Institute of Technology, Chicago, June 21-25, 1965. (Mimeographed.)

> Thus, companies generally are beginning to re-evaluate their positions on this matter, and they recognize that, at the very least, a mutual responsibility exists.

Expressing the distribution of responsibilities in an abstract way is clear enough, but it does not necessarily reflect what all or most employers, professional socieities, and universities are actually doing. Each of these three has its own specialized capabilities and its own motivations in continuing education, its own special relationship to the individual to be taught or seeking to learn, and a different set of points of view. Furthermore, each has its own motivations, which interact with each of the others, and the motives (etc.) are not identical in every member of any of the interested parties -- not in the individuals, universities, professional societies, or employers. In the interfaces among these last three, and in how these interfaces affect the individual, there are some current issues of interest which the remaining part of this chapter attempts to summarize.

The Role of the Individual. The responsibility for self-development may be expressed in two ways, either emphasizing basic motivation or extending motivation into action. First, the individual must supply the energy and initiative necessary to motivate learning. Without internal drive, individuals are unlikely to benefit from any educational experience. The individual cannot passively sit back and expect to be spoon-fed the knowledge he needs. Second, he must be alert enough to recognize his needs for learning, motivated enough to seek opportunities, and farsighted enough to make plans for fulfilling his needs. In spite of standardized curricula and impersonally rational job specifications, it is likely that no one else is in as good as, or better position than, he to determine what he needs to know and whether this need is a matter of updating or of an extending of his competence into areas considered critical to his professional growth. Best quotes a number of comments, among them the following sharp but colorful statement from an engineer:[18]

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[18] Robert D. Best, "What Engineers Want." Chemical Engineering Progress, LXII, No. 5 (1966), 51.

> Lots of engineers around here expect management or someone else to squeeze a glass of fresh knowledge for them every day and then see that they drink it! But I guess you can only decide for yourself what to study when you know what kind of a person you want to be ten years from now and what you will want to be doing.

Employer Programming. Those employers who accept at least a mutual responsibility (with the individual) for continuing education think in terms of (1) costs and (2) opportunities for continuing education activities which will directly benefit the individual and the organization. As Haber has said:[19]

> Decisions must be made for underwriting of costs and time -- the level and nature of company support. Company goals will help determine these decisions, as will economic constraints (short-term or long-term needs and resources to support them), technical fields on which the company depends, and effects of productivity and turnover which change the levels of support. The nature of support must be based on both the company and the individual needs.

Mr. Haber continues at another point:

> Of the modes of continuing education available, none, one, or all may fit an individual. Each has its fine points. However, newer ways are coming that must be promoted to cover the ground faster for the trained professional, offering a nearly continuous exposure to upgrade [him].

Another facet of employer programming for continuing education is structuring the job and the work environment so that the individual has time to keep himself up to date, or to catch up if needed. The literature contains various proposals for devoting one day a week to keep up to date, or five hours, or 5 percent of the work week. None of these appear to have received widespread acceptance, probably because no one of them fits the majority of established work schedules. If keeping up to date, or catching up, were simply a matter of self-teaching through reading, perhaps some specific number of hours would be a reasonable proposal, but some modes of continuing education require varying-sized blocks of time. Also, as the magnitude of technological change becomes greater, the individual is less and less able to keep up to date solely on his own time. Consequently, many writers on continuing education are calling for a rethinking of the job format to include time to keep up to date, not only in the specialty of the job assignment but in broader areas where new developments pertain to the spectrum of the incumbent's original training and present interests.[20]

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[19] M. F. Meer, "Responsibility in Continuing Engineering Education." Northwest Professional Engineer (Winter, 1967-68), p. 20. This is a summary of panel discussions at the AIAA 4th Annual Meeting, October, 1967. The remarks quoted are by Mr. B. D. Haber, Vice President, North American Aviation, Inc.

While a number of outstanding employer programs in continuing education are frequently cited in the literature and have been influential in setting the pace and quality of other programs, it appears that a substantial percent of the employers of engineers do not support continuing education to any appreciable extent. Unfortunately, few hard facts are available for estimating this proportion reliably. The PEI report, previously cited, states (p. 21) that "over 60 percent of the costs incurred in participating in any formally organized continuing education programs were at the personal expense of the respondents." This indicates that a significant part of the burden of costs is still borne by the individuals. Moreover, only 36 percent of these PEI respondents (p. 18) participated in company-conducted continuing education programs (costs to the individual, if any, are not reported by mode of education). While we cannot assume that every engineer who had employer-sponsored programs available participated in them, the inference from these figures is that many employers do not support engineering personnel in any of their continuing education efforts. Additional evidence is found in the many reasons cited by PEI respondents for non-participation, including lack of time, pressures of work, and no assistance from employer (actual frequencies are unreported). Our own data on these points of time, costs, and opportunities are reported in Chapter III.

The University-Employer[21] Interface. The word "interface" refers to the complex set of interactions by which ideas and personnel permeate the common boundary which universities and employers share. In general, purposive interrelationships exist in order to arrive at mutual understanding, respect, and cooperative efforts in solving common problems. Cooperating to solve continuing education problems is only one part of the university-employer interface. In the literature on continuing education, it is not uncommon to find discussions and recommendations which define what general form these relationships should take and what is the proper role and responsibility of universities and employers in general.[22] There is less frequently explicit recognition of the fact that the interrelationships with employers which make up this abstraction are quite different from employer to employer and from university to university.

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[20] Samuel S. Dubin and H. LeRoy Marlow in their study of Pennsylvania engineers (previously cited) make this part of their first recommendation for employers.

[21] We use the term "university" to include universities and colleges and "employer" to include both industrial and Federal Government employers of scientists and engineers.

The literature includes excellent summaries of the issues in the interface between universities and employers, which explicitly note the difficulties impeding the development of well-planned and broad-guaged continuing education programs. A report prepared for the President of the University of California states:[23]

> The need for the University to contribute to continuing engineering education even today far exceeds the very substantial effort being made. Problems include the minimal financial support, the lack of long-range planning, and the general lack of faculty participation.

This report recommends a mandatory role of the university in accepting responsibility for continuing education of equal importance with undergraduate and graduate training. The continuing education issues more specifically spelled out in this and other reports are:

1. Defining the needs to be met.
2. Credit versus non-credit, and, related to this, maintaining academic standards versus the practical approach.
3. Obtaining a degree versus enhancement of professional competence.

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[22] For example, Toward a Better Utilization of Scientific and Engineering Talent -- A Program for Action, Publication No. 1191. Washington: National Academy of Sciences, 1964. Also see the Goals Committee and the JAC reports (previously cited).

[23] An Engineering Master Plan Study for the University of California. Berkeley: The Engineering Advisory Council, University of California, September, 1965, p. 99.

4. Who will teach: regular faculty, qualified outsiders, or extension and night-school faculty.

5. Lack of involvement of regular faculty, and even hostility on the part of some of them, to continuing education programs.

Commenting on some of these issues, Briscoe concluded:[24]

> ...Continuing education should be a major responsibility of the academic community, complementing regular degree programs in much the same way as research now complements instructional activities. Industry, on the other hand, "must reassess the nature of its support." Understanding between these two major segments of society must increase. If industry and the university were to resolve all specific issues, there would be little to deter the development of continuing engineering education.

Those who write on this subject agree that the university should be both a resource and a leader in developing continuing education programs with industrial and government employers. Since these writers note the lack of involvement and hostility of regular faculty, it is somewhat provocative and revealing that those faculty holding the negative point of view have yet to be heard from (see Chapter IX). The literature cites numerous cooperative efforts of universities and employers working together to implement one or another continuing education program.[25] Very infrequently does there appear any case where efforts failed, or where a relationship once established was terminated. The only mention of this we found is reported by Science magazine quoting a study by the Federal Council for Science and Technology:[26]

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[24] M. F. Meer, "Responsibility in Continuing Engineering Education" (previously cited), p. 8. The remarks quoted are by J. W. Briscoe, Associate Chancellor and Professor of Civil Engineering, University of Illinois.

[25] For example: "UC Extension Keeps the Pros Up to Date." Business Week (March 12, 1966), pp. 196-202, reports the range of continuing education activities for professional people at the University of California. Also, "Engineering Courses Emphasize the Practical." Chemical and Engineering News (October 2, 1967), pp. 52-54, reports on Monsanto and Washington University's mutual efforts. Also, "ATAC Schedules Effort to Update Personnel." Army Research and Development News Magazine (June, 1967), pp. 1ff., reports on the program of the Army Tank-Automotive Command and five Detroit area universities. We cite these latter two as illustrative of recent examples. There are other well-known examples, however.

> ...There is a noticeable tendency on the part of some universities to withdraw from cooperative educational endeavors with Federal laboratories, affecting both after-hours educational programs and the university's regular advanced degree programs. Some universities that in the past cooperated in setting up extensive after-hours programs, are currently reluctant to extend them or to participate in similar new programs with other laboratories. In at least one case, a university is withdrawing completely from an extensive program of many years standing, thus precipitating a crisis at the affected Federal laboratory. [Science comments that no details are offered on this case.]

This may be regarded as a counter-movement to the direction which is thought most desirable by employers, which has been fostered by professional societies, and which (following Sputnik) was demanded by the society at large.

As part of this study, academic people were interviewed in some universities and colleges located in the same communities as the laboratories studied. Chapter IX presents some of the differing points of view expressed about these issues in the university-employer interface.

The Professional Societies and the Individual. The 1960's have seen a tremendous increase in the range and extent of continuing education activities by professional societies. The engineering societies and the American Chemical Society have been most active in seeking to develop and implement new methods of meeting continuing education needs of members. While professional societies have always had the responsibility for disseminating information on new developments through publications and meetings, the trend in the current decade has been to develop mechanisms for planning, coordinating, and implementing more organized forms of dissemination and instruction. We may summarize what leading societies are doing as follows:[27]

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[26] D. S. Greenberg, "Federal Labs: White House Study Urges Closer University Ties." Science (January 26, 1968), p. 413.

A. Dissemination of information

1. Journals covering new developments, knowledge, and techniques and presenting specific scientific and engineering data.
2. Other technical publications, including transactions, proceedings, abstracts and bibliographies, monographs, and other specific and detailed technical information.
3. Non-technical publications, containing news both of general interest and specifically pertaining to continuing education as well as technical articles of broad general interest. Chemical and Engineering News is an excellent example of this type of publication.
4. Annual meetings, including both the traditional presentation of papers and discussions and the newer formats of short courses, review, and state-of-the-art papers as part of the meeting.

B. Planning, coordinating, and implementing specific continuing education activities aimed at updating and keeping up to date to overcome or prevent obsolescence.

1. General guides for local chapters or sections for planning continuing education activities from inception to implementation.

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[27] For examples, see: (1) Moses Passer, "Continuing Education for the Chemist: The Role of the American Chemical Society." December, 1964. (Mimeographed.); (2) "Continuing Education for Each Technically Trained Person Is a Must." Chemical and Engineering News (March 14, 1966), pp. 16A-19A, outlines the activities of the ACS and other technical societies; (3) William A. Conwell, "Continuing Education -- What ASCE Is Doing." Civil Engineering -- ASCE (May, 1965), p. 32; (4) Monroe W. Kriegel, "A Program for Improving the Technical Competence of SPE Members" (previously cited); (5) Continuing Education: A Manual for Society of Petroleum Engineers of AIME Local Sections. Dallas: Continuing Education Committee of the Society of Petroleum Engineers of AIME, 1966. (Mimeographed.); (6) SPEEA Plan: Continuing Engineering Education. Seattle: Professional Engineering Employees Association, January, 1965; (7) Engineering Education in Plastics. Stamford: Society of Plastics Engineers, Inc., 1961, which outlines the recommendations of the society for university curricula; (8) Annual Reports of 1964 and 1966 and other unpublished documents by the Committee on Continuing Education of the American Society of Mechanical Engineers, which outline the accomplishments, plans, and materials provided to local sections.

2. Specific instructional materials or recommendations for where they can be obtained for local use.
3. Speaker-lecture tours and touring short courses.
4. Surveys of members to determine their needs, interests, and attitudes regarding continuing education. The society is a mechanism for quickly and readily obtaining information on new developments as well, because of the dispersion of its membership geographically and their involvement in all aspects of the fields or disciplines which the society represents.
5. Cooperative efforts with other societies, universities, and employers in solving problems and meeting the needs in continuing education.

These nine activities are educational in the broadest sense. That is, they alert the individual to new knowledge and technology, make available specific information pertaining to their use, point out the broad implications of these developments, and provide instruction designed to make them readily available to the members.

In addition, the Engineers Joint Council for Professional Development (made up of nine leading engineering societies) in 1965 established a permanent Committee on Continuing Education with a full-time director. The function of this office is to continue and expand the development of the kinds of programs and activities listed above. This is an instance of how societies can cooperate on mutual problems shared by their membership.

The issues in professional society activities focus on expanding to meet the need, developing the kinds of arrangements which make it possible and convenient for members to participate, and investigating new methods and ideas in continuing education for possible application.

The research reported here does not specifically examine the range of professional society activities. It underplays their importance and vitality. However, attending professional meetings, short intensive courses, and reading the literature are identified as specific modes of continuing education. Professional societies are often sponsors of the first two and, in their publications, responsible for much of the literature.

Conclusion

The concept of continuing education which emerges from an examination of the literature is heavily influenced by the phenomenon of technological obsolescence. Since the military and political spurs to increasing knowledge and technological effectiveness in World War II and its aftermath, the accelerating growth of knowledge and technology has decreased the "durability span" of traditional academic training to such an extent that continuing education is a vital technique for preventing extensive obsolescence during the career of any professional person.

The literature reflects practical and immediate concerns as intrinsic to continuing education, and it shows a somewhat simplistic tendency to assign responsibilities and activities piecemeal among individuals, employers, universities, and professional societies. In spite of reported economic (and, indirectly, competitive) pressures on employers to contribute to updating and diversification of their engineers and scientists, there are few indications of coherent or widespread attention to the activity. Similarly, there is a clear tendency to dissociate advanced degrees from anti-obsolescence activities in educational spheres, and there are many suggestions that university and college faculties are frequently indifferent or actively resistant to continuing education activities. Professional societies have made distinct inroads and contributions to both the dissemination of information and the implementation of specific continuing education programs and concerns, while their somewhat ancillary and diffuse position necessarily makes their impact different from that of employers and universities -- both for better and for worse.

With this background of the pertinent literature, we clarified our definition of continuing education, which accepts the widely-asserted one of eliminating advanced degree-seeking, management and communication training, and any training not focused on the special scientific and technological fields of the professional's work, and which further accepts the pragmatic assignment of concern to (a) individual professionals, (b) universities, (c) employers, and (d) professional societies. The objectives of the present study are given in the next chapter.

CHAPTER II

PURPOSE AND SCOPE OF THE STUDY

Purpose

The purpose of this study is to collect and interpret facts relating to the need for, and use of, continuing education by research and development scientists and engineers in large industrial and government R&D laboratories. This study will also identify, describe, and appraise a number of continuing education programs currently in use and the work context or environment in which such programs are available. The results of the study will also provide guidelines to employer organizations considering adopting or expanding continuing education resources for their professional personnel. Other more specific purposes are listed below, but this general statement gives the study's emphases on describing existing employer programs as well as the use and appraisal R&D personnel make of existing opportunities.

Basically, the study seeks to explore nine interrelated questions:

1. What are the needs in continuing education expressed by research scientists and engineers in the context of their own work?
2. What is the kind and degree of the scientists and engineers' participation in continuing education; and what is the relation between the latter and the continuing education policies and practices of their employers?
3. What are the scientists and engineers' interests and motivations in pursuing continuing education?
4. What are the differences, if any, between scientists and engineers in research with respect to continuing education needs, interests, motivations, and activities?
5. What differences, if any, exist between scientists and engineers in research with respect to these matters and those issues already reported in the literature for engineers in general?
6. What are the modes of continuing education R&D professionals use, who sponsors them, and how do the scientists and engineers evaluate and appraise the modes used?
7. What are the specific components of employer programs and the employer policies and practices which govern their use and implementation?

8. What do responsible executives in R&D laboratories say about continuing education: How do they view both the issues involved in continuing education and their own employer programs and practices aimed at resolving these issues?

9. What is the relation between the R&D employee's work environment and his participation in continuing education?

Scope

The study was designed to collect data in 17 large R&D laboratories and in nearby colleges and universities. Nine of the laboratories are industrial and eight are Federal-Government-owned laboratories. There are three sources of data:

Top Management. These data come from 95 interviews in 17 laboratories with the chief R&D line executives and personnel and training executives. The interviews focused on the executives' appraisal of the effectiveness of the employer continuing education policies, programs, and activities. These executives supplied most of the information on employer policies and practices. Records pertaining to continuing education (expenditures, participation, etc.) and other documents (policy statements, brochures, etc.) were examined and collected wherever they could be obtained. However, records were available only to a limited extent and were largely fragmentary.

R&D Scientists and Engineers. These data are of two types, qualitative and quantitative.

1. Interview Sample. There are 205 interviews with scientists and engineers including 54 supervisors immediately above the working level. These were obtained in ten laboratories, approximately 20 in each. Each interview lasted about one hour and was recorded as nearly verbatim as possible. The form of the interview was a discussion with the interviewer using a prepared list of questions to stimulate conversation about the individual's continuing education activities, his motivations for engaging in them, his appraisal of his experience, and his present needs. These data are qualitative, that is, not amenable to statistical analysis.

2. Questionnaire Sample. In nine of the ten laboratories in which personal interviews were obtained, a questionnaire was administered to additional scientists and engineers. This questionnaire was structured and designed to yield quantitative data which could be treated

statistically. There are 394 usable questionnaire obtained from these nine laboratories.[1]

Academic Personnel. Interviews were held with 71 academic people in 24 universities and colleges located in the same or nearby communities as the 17 laboratories. The interviews focused on the individuals' philosophy and attitudes toward participation in continuing education and their evaluation of their continuing education programs if any were available through their school.

Nature of the Sample

The study sample is not random: it was designed to include the kinds of persons and organizations which could contribute to the study objectives.

First, three criteria were employed in selecting the 17 R&D laboratories:

1. A budget of ten million dollars or more. This insures that the laboratory is large.
2. A work force of at least 250 R&D scientists and engineers, of whom not less than 25 percent are research scientists. This insures that an orientation to science will characterize a significant part of the laboratory's work force.
3. A claim to have some program of continuing education over a period of at least three years. This insures that the laboratory will have some experience with continuing education.

Taken together, these criteria eliminated small laboratories, those composed overwhelmingly of engineers, and those oriented mainly to routine kinds of development, with only minor emphasis on research.

In the selection of scientists and engineers to be interviewed and to complete the questionnaires, employers were asked to eliminate both employees primarily providing technical services to others and those engaged in research to improve already existing products or processes. A further restriction was a quota of two scientists to one engineer, carefully chosen so as to cover the spectrum of R&D activities from research to development. Finally, for the personal interviews, employers were asked to select four or five (out of 20) first- or second-level supervisors -- that is, men who either directly supervised working scientists and engineers or were just one step higher. Supervisory personnel were excluded from the questionnaire sample.

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[1] Because of their length, the interview guide and the questionnaire are not reproduced in this report. Copies may be obtained by writing to the principal investigators.

These criteria resulted in a sample of men engaged in research important to new knowledge, with scientists outnumbering engineers. Supervisors just above the working level were included in the interview sample to get their ideas and experiences in encouraging or discouraging continuing education for subordinates, as well as for information on their experiences and reactions. Higher level supervisors and managers were considered to have continuing education needs sufficiently different from the practicing scientist and engineer to be excluded from this study.

The concern throughout this study is with people engaged in research. R&D as conceived in these 17 laboratories covers a range of work activities. Some of these activities require competence on the cutting edge of new knowledge -- what is called "research on the frontiers of knowledge." Other persons are engaged in applications of knowledge requiring less up-to-date knowledge of new developments at the frontiers. Thus, the spectrum of interviewed persons ranges from those creating new knowledge to those who are applying rather than creating it.

Both engineers and scientists are found throughout the R&D spectrum. However, the sample has more engineers in the development end of the spectrum than in research, and vice versa for scientists. Because of this mixture, few definitive statements are made about differences between R&D scientists and engineers. Rather, the distinguishing variable is whether or not the individual is working on the frontiers of knowledge. As compared to the population from which it was drawn, the sample is rather skewed in the direction of work on the frontiers. This was desired and intended in order to focus on continuing education in a research context but without excluding all others also working in R&D.[2]

The term "sample" is used as a convenience. Actually, this sample is neither random nor statistically representative. Thus, statistical results reported here are not to be extrapolated to the R&D population at large. This study is primarily qualitative; in it, statistical results are used descriptively to focus and illuminate the qualitative findings. Even the quantified questionnaire contained items which individuals answered in their own words. In every sense, this is an exploratory study and not intended to be definitive in a statistical sense.

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[2] These criteria have, however, resulted in some anomalies in the statistical results: See Chapter IV, footnote 1.

Modifications in Original Design

In the proposal, the study design required 20 laboratories rather than 17. In ten of them, only top-management personnel were to be interviewed; in the other ten, the interviews with top management were to be supplemented with interviews and questionnaire data secured from employees. As it turned out, by the time data had been collected in 12 laboratories and the cooperation of five others had been secured (which required obtaining preliminary information), it was apparent that the original conception of unique and distinctively different types of employer programs of continuing education was erroneous.

The data to be reported show that employer programs are similar from laboratory to laboratory in both industry and government. Employers in general make use of a limited number of different educational experiences, which we call "modes." Six employer-sponsored modes of continuing education are distinguished which will be familiar to most readers: (1) university credit courses with tuition refunds, (2) in-lab employer-sponsored and taught courses, (3) short intensive courses away from work, (4) attendance at professional meetings, (5) in-lab lectures and seminars, and (6) leaves with pay. Because of this uniformity, it did not seem necessary to extend the number of laboratories beyond the 17 already secured. Rather, the time and budget were used to increase the number of personally-interviewed scientists and engineers from the 162 originally called for to 205 in order to explore in greater detail what individuals do about continuing education within the context of the employer-sponsored modes.

In accordance with the proposal, one or two organizations were sought which had decided not to support continuing education for research people. No such organizations were found among the 35 for which preliminary information was developed. The closest to "no program" is one laboratory which limits its educational support to tuition refunds for university credit courses, participation in a reduced-time degree-seeking program, and only occasional use of other modes. This laboratory is one of the 17 included in the study.

A number of issues in continuing education which might be relevant to the findings presented in this report were not explored. The boundaries of the research are drawn in accordance with the questions and criteria set forth above. Many readers will raise questions about one or another issue which we did not set out to study and on which we make no comment. One is the impact of curriculum change in the past ten years on the quality and quantity of continuing education efforts of more recent graduates as compared with older graduates. Since we did not study these curriculum changes, and indeed know very little about them, readers seeking an exploration of this issue will not find it here. There are other issues which we set out to study for which we did not develop fruitful or meaningful data. One of these is the relationship between the environment and involvement in continuing education. We had thought that those persons working in a more open, autonomous, loosely coordinated research environment might be more stimulated to engage in continuing education than those in more closed, coordinated, and directed research environments. The data collected neither support nor deny the validity of this hypothesis, and, in the interest of brevity, we do not dwell on them at any length. What we have to report about environment and motivation is contained in Chapter VIII.

CHAPTER III

EMPLOYER POLICY AND PRACTICE

This chapter deals with continuing education in relation to the employer philosophies, programs, and practices of the 17 laboratories. The Joint Advisory Committee report on Continuing Engineering Studies makes several recommendations for industry which are just as pertinent to employers today as they were in 1965. Three of these are particularly relevant to setting the stage for this chapter, and they apply to both industry and government employers. These are:[1]

> 1. Industry must take the initiative and responsibility in defining a continuing studies program, recognizing it as a management tool that can be used to attain company objectives.
>
> 2. A continuing engineering studies program must have a sufficient number of alternatives in order for each engineer to select and integrate what is useful and needed by him.
>
> 3. (JAC #9) Programs of continuing engineering studies should be established with deliberate objectives.

The JAC report makes explicit that the organization's motive in supporting continuing education is not altruistic but to keep "its technical manpower force as closely coordinated as possible to a rapidly changing technical world." The rationale behind this motive is largely economic -- to remain competitive and to maintain the quality of the resource which highly trained technical manpower represents.

Top Laboratory Management Philosophy

The findings presented in this section are based on interviews with 95 top laboratory management personnel:

33	Top laboratory directors and managers
36	Chief personnel and training executives
9	Other managers in top management
17	Library directors

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[1] See JAC report, previously cited in Chapter I, pp. 45 and 48.

Throughout this report, any statement about top laboratory management refers to this set of interviews.

The top laboratory managers in both industry and government who were interviewed generally agree that the employer has a responsibility to provide opportunities for continuing education to scientists and engineers employed in the laboratory. While it is acknowledged that this will benefit the individual personally, the basic justification is employer self-interest. An intensity of conviction is reflected in the way almost all top managers talk about the need for continuing education:[2]

> I personally regard continuing education as a matter of life and death for a company. In the present exponential rate of increase of knowledge in all the scientific fields, I don't see how we can do anything but keep running very hard to stay competitive. It's very important for the management of a company to create an atmosphere that says, "Look, we want you fellows and are counting on you to do this, and it's really part of your job." It wasn't very long ago when the engineers and the scientists were expected to do their continuing education on their own time. That attitude tends to prevail on the part of the older management types still.
> Vice President and Chairman of the Education Committee, Industry

> We don't hire and fire people. Our lab is aging six-tenths of a year per calendar year. How are you going to keep your people young unless you keep them in touch with the scientific community? It's necessary to do this. I don't recall any individual coming up here and saying his branch chief wouldn't let him go to school.
> Director of the Laboratory, Government

> It is not a question of how continuing education benefits the laboratory. It is a question of what happens to your laboratory if you don't support continuing education for your people. You die.
> Top Manager, Industry

We wish to stress that management objectives are not pinpointed to the needs of individuals; they are directed to the work force as a whole. There is, then, a difference in perspective between management and the research employees. The latter are primarily concerned with themselves and their own continuing education needs for enhancing job competence and advancing their careers. Management, on the other hand, is concerned with continuing education as a means to a broader objective, that is, to the accomplishment of the laboratory's mission. Thus, the individual's needs are secondary to the collective needs as defined by management. From management's point of view, the individual must fit himself and his needs into the range of opportunities designed for the collectivity. Thus, there is a *potential* for conflict and/or personal frustration as particular individuals attempt to fulfill particular needs within the range of opportunities provided.

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[2] In this report, quotations from the interviews are always shown single spaced and indented. Top managers are identified by title; others are identified by the individual's highest degree, the discipline in which the degree was granted, and his age. If he is a supervisor, this is also noted. These quotations are illustrative; the findings as reported are based on an examination of all the data.

Top laboratory managers also say the individual scientist and engineer has a responsibility to make use of employer-provided opportunities as well as of other opportunities. The general belief and attitude is that the individual is responsible for keeping himself up to date by investing his own time in continuing education off the job. Such effort is viewed as a self-evident element in professional competence.

Top laboratory managers also believe that individuals who are insufficiently motivated to keep up to date are not salvageable by continuing education methods. The literature frequently mentions the problem of motivating men who do not combat their own technological obsolescence. Therefore, top managers were asked about their views and experiences on this point. They believe that those who are low on internal drive, aspiration level, and/or ability cannot be "rehabilitated" (at least by the employer) to extend themselves beyond whatever level they set for themselves. Direct employer responsibility is seen as ending with the provision of opportunities for those individuals who have the drive, ambition, and ability to seize the initiative.

When top laboratory management people are asked what is done with these unmotivated people, they report that the tendency is to put them on the shelf and forget them. There are many jobs in the laboratory these people can do, not requiring strenuous efforts or time off the job for keeping up to date. Top managers say the unmotivated are moved, or move themselves, into such jobs, or they move out of research into other lines of work. (Management also has the option of firing them; the extent to which firings and layoffs have occurred in these laboratories was not determined. However, the study took place in a tight labor market; attrition because of firings is probably low at such a time.) So far as can be determined, top laboratory management does not take direct action with respect to individuals; that is the job of the lower levels of management and supervision. Supervisors to whom this task is delegated recognize two types of unmotivated persons: the narrow specialist and the person who prefers doing what he knows best and declines opportunities to expand his capability. The supervisors' views and behavior in encouraging continuing education are presented in Chapter VIII.

Management's Continuing Education Objectives

Laboratory managements do not clearly differentiate continuing education objectives from upgrading as defined in Chapter I. Those objectives, as stated by top managers, which pertain to continuing education are given here. Their objectives in supporting degree-seeking activities are presented at the end of this chapter. Since degree-seeking is not an integral part of this study, the information collected on this aspect of employer programs is separated from that dealing with continuing education. Additional facts on educational leaves with pay to seek a degree and comparable facts on sabbatical leaves for other purposes are presented in Chapter VI. Degree-seeking activities are not otherwise discussed at any length in this report.

Employer objectives pertinent to the quality of the work force are broadly defined. Continuing education activities are only one possible strategy for achieving them. Recruiting, hiring, placement, transfer, rotating job assignments, and firing are other personnel techniques which are also used to enhance the quality of the work force in particular ways.

We can identify five management objectives which continuing education activities can help them attain:[3]

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[3] This list of objectives is based on the interviews with top laboratory management and chief personnel and training executives as well as on documents pertaining to continuing education developed in these laboratories and supplied to us for information purposes.

1. To achieve specialization or acquire capability in particular disciplines, new fields, or techniques. (Degree-seeking support could also be classified under this objective.)

2. To permit individuals to make progress in their assignment by acquiring knowledge needed as a basis for progress.

3. To provide refresher and updating opportunities for those who need them in order to maintain them at a high level of work performance.

4. To reorient in mid-career a select few of the senior and productive research people who need and desire a revitalizing and refresher experience such as that provided by a full-time leave.

5. To encourage keeping up to date by ensuring that scientists and engineers have sufficient opportunity to develop and enhance their professional stature by attending meetings, publishing papers, and holding offices in learned societies, all for the purpose of keeping in touch with the wider world of science and engineering outside the laboratory.

These five objectives are overlapping and not totally within our definition of continuing education as limited to refreshing, updating, and diversification.

Employer Programs

Table III-1 presents a summary of the employer programs of continuing education in the 17 laboratories participating in this study. Four of the employer-sponsored modes are listed under "Outside Lab," and two others plus "Major Conferences" are listed under "Inside Lab." (Major conferences are professional meetings, but are employer-sponsored and held on or near employer premises. Panels, papers presented for discussion, and other activities characteristic of professional society meetings are features of these major conferences -- indeed, such conferences are often jointly sponsored with professional societies. However, attendance is by invitation. They appear in the table because they are integral to the "keeping up to date" efforts of six laboratories, and because they serve the same purposes as other professional meetings.)

Table III-1 makes two points. The first is that three modes of employer support are almost universal. Sixteen laboratories pay expenses to professional meetings, 17 give tuition refunds for university credit, and 14 also have regular series of in-lab lectures and seminars. At the other extreme,

TABLE III-1

COMPONENTS OF CONTINUING EDUCATION PROGRAMS LABORATORY BY LABORATORY

	Outside Lab:				Inside Lab:		
Laboratory	Expenses Paid to Meetings*	Courses with Tuition Refunds	Sabbatical Leaves with Pay*	Outside Short Courses*	Lectures	Courses	Major Conferences
Industry							
1	X	X		X	X		X
2	X	X	X		X		X
3	X	X		X	X	X	
4	X	X	X		X	X	
5	X	X	X		X	X	
6	X	X	X		X		
7	X	X	X		X		
8	X	X					X
9		X					
Government							
1	X	X	X	X	X	X	
2	X	X	X		X	X	X
3	X	X	X	X	X		X
4	X	X	X	X	X		
5	X	X	X		X	X	X
6	X	X	X		X		
7	X	X		X			
8	X	X	X	X	X	X	
TOTALS							
Industry	8	9	5	2	7	3	3
Government	8	8	7	5	7	4	3

*Employer policy is such that this mode is not uniformly available to all R&D scientists and engineers.

there is sharp inconsistency in the use of outside short intensive courses and in-lab courses sponsored and taught under laboratory auspices. Table III-1 shows the components of continuing education which employers put together in various ways to create their "program." The six employer-sponsored modes of continuing education are discussed in Chapters V and VI, and further details of employer policy are given there.

The second observation that derives from Table III-1 is that the employer programs are essentially similar. The one notable exception is Industry #9 which provides only tuition refunds to its R&D personnel for continuing education. (This employer is also heavily involved in a reduced-time, degree-seeking program so that it has an educational program which goes beyond continuing education.) In addition, Industry #8 and Government #7 sponsor only two and three of the six modes respectively. With these exceptions, industry tends to sponsor four or five of the six modes, and government five or six of the six modes. These uniformities are the basis for saying the "programs" of continuing education are essentially similar from laboratory to laboratory.

Employer programs, then, consist of sponsoring various modes of continuing education to achieve one or more of the five objectives listed in the previous section.

Determining Continuing Education Needs

Nine laboratories (four industry and five government) have committees to consider needs, costs, and programs of development for professional personnel. These committees are relatively small, ranging in size from three to about fifteen persons and usually including personnel and training experts along with representatives of top management. Other members are drawn from the professional work force. Normally these committees meet regularly, although not necessarily frequently, to consider problems of continuing education as well as other techniques of professional development. Their function is to recommend specific courses of action to top management. Almost always, questions concerning the advisability of doing one thing or another in continuing education are first referred to this committee or originated by it. As a medium for discussion of the merits of an issue in continuing education prior to making a decision about it, these professional development committees perform a valuable service.

A training officer in a government laboratory described how one professional development committee has worked:

> The present full and three-quarter time program of people going back to school was discussed in detail with this committee three years ago. I think the committee had a good deal to do with this laboratory going into this full salary and full tuition program. Since then we have tried to keep track of it and see how it is paying off. We can compare the number taking part in this now and the number before who were going to school. Now there are a number of things being discussed, such as the utilization of television to get courses without leaving the station. The committee members are active in keeping the Technical Director aware of what is needed and in getting plans initiated and approved by him.
>
> Training Officer, Government

Six of the laboratories (two industry and four government) systematically survey educational needs, using questionnaires and/or interviews. Four of these six (two each in industry and government) also have professional development committees. These surveys are made annually or every two years to ascertain what professional people say their continuing education and other education needs are.

Another method, found only in one government laboratory, ties a determination of continuing education needs to the performance appraisal system:

> Performance appraisals are reviewed by the training staff to see what the supervisor and employee have agreed on. There is a 60 to 90 day follow-up on new personnel or new promotions or new assignments to see if training is needed. It is done each time an assignment changes. A form goes to the supervisor and asks him what the employee needs. It must be completed by the supervisor. The initiative of the employee is great. The employees here know they can get training if they want it. This has created a change in climate in which an employee can seek whatever training he needs.
>
> Training Officer, Government

The remaining five laboratories use what may be called the "seat of the pants" method. Information is obtained in ordinary day-to-day contacts between decision-makers and the professional work force. Although possibly effective in small laboratories, the reliability of this method is questionable, especially in larger laboratories.

Evaluating Effectiveness of Continuing Education

None of the 17 employers report any systematic research or measure designed to determine the benefits of continuing education either to the laboratory or to the individual. Indeed, for the most part, continuing education is assumed to be beneficial to both.

When asked to evaluate their programs as to the adequacy of scope and effectiveness, managers typically hedge their replies by saying that they are not doing enough or could do more. On the other hand, with respect to specific modes of continuing education which they support, top management and chief personnel and training executives usually simply report that the activities are "working well." (By contrast, most employers can report how many persons have been supported in obtaining a degree; the degree is taken as the measure of quality.)

Although management has not undertaken any systematic evaluation of their continuing education activities, almost all of those interviewed regard continuing education as an essential part of the laboratory's over-all efforts to keep the professional work force up to date. The following three comments illustrate the prevailing opinion:

> One measure is whether your designs in engineering are competitive in the sense that you are using the latest technology that is practical to apply, or whether you are sticking to the old-fashioned ways. This gets sharpened up because the new technologies enable us to do things with less power. But if we don't stay up with the developments in the field and try to apply the new technology, the inevitable will happen. We will fall flat on our face. Our product is looked at very closely by the military. They will tell us very quickly.
>
> Vice President of Research, Industry

> Reactions to continuing education among our executives are very mixed. From complete rejection to "so what" to enthusiasm.
>
> Top Manager, Director of Chemical Research, Industry

> If you have the people on your staff who can grasp a new direction in research and go with it, that is the measure of how well you're doing in continuing education.
>
> Laboratory Director, Government

Whether these evaluations can be considered "measures" or not, they do leave the impression that, in general, top management is satisfied that continuing education efforts do benefit the laboratory and are essential to it.

In spite of the lack of systematic evaluation of continuing education activities, supervisors do judge whether an individual is up to date and evaluate his capability and job performance. This is not an evaluation of the continuing education activities themselves but may take the form of a judgment concerning the need for them. What supervisors do and how they go about it, in respect to continuing education for their subordinates, is the subject of the first part of Chapter VIII.

Government vs. Industry Programs

There is a degree of uniformity among the continuing education programs of the government laboratories which is not found in industry. That both the provisions themselves and their implementation are similar from one government laboratory to another to a greater extent than in industry is a reflection of the Government Training Act of 1958 and subsequent amendments to it. The Act is the legislative authority for training and education of civil service employees in Federal employment. When government laboratory directors and other top managers are asked what part the Act played in their continuing education programs, the consensus is that the Act with amendments now provides ample authority for whatever educational programs are needed. The Act is seen as a positive force in creating training and educational opportunities. The Act is implemented by parent agency directives and generally does not have a direct, traceable impact on specific educational activities. Within the framework of agency directives, laboratory training and educational programs are developed. Thus, the actual programs and administrative practices in the individual government laboratories are initiated by them.

Referring again to Table III-1, it can be seen that the government programs are by and large similar in the components they use. Among the 17 laboratories studied, there are somewhat more opportunities for continuing education in government than in industrial employment. Even on tabulation the government laboratories, on the average, sponsor five components to industry's average of four.

Educational Expenditures

By and large, cost records are not kept in any way that makes them usable for research purposes. It was not possible to determine with precision exactly how much money is spent on the different modes sponsored by management. Just as employer programs are not identical, neither do employers keep the same set of records on costs of these programs.

However, the following observations are of interest:

1. Most laboratories have no single budget for all educational expenditures. Rather, there are budgets for specific programs, particularly for direct payments to individuals for refunds or to universities and colleges for refunds and other expenditures. However, these records do not reflect the difference among payments for graduate study in reduced-time programs, for educational leaves, and for continuing education purposes. In some laboratories, the payment records include expenses for outside short intensive courses; in most laboratories, there is no record at all of expenditures for outside short courses.

2. In some laboratories, cost records cover the total work force, of which the professional personnel are only a small part. Where this is done, it is impossible to determine just what part of the costs are for continuing education in science and engineering and what part are for other types of training.

3. The lack of accurate information on expenditures for continuing education does not seem to concern top managers. They see no need for, and do not wish to keep records which reflect, the actual costs of the different modes.

4. This situation has also been reported by others. For example, the Presidential Task Force on Career Advancement took issue with the government agencies for not analyzing training costs in relation to benefit, including continuing education. They recommend not only that such analyses be undertaken, but also that they be made mandatory in agency programs.[4]

Accurate record information is useful in various ways. Among these are: to document what has been done, to aid in projecting future plans, and to measure the extent of participation in continuing education. The last is of most concern to this study. While we can report the number of people in the study sample who have engaged in one or another of the modes, there is no base for comparing these figures with what is typical for any one of the laboratories or for all of them as a group. Knowing how many people are, and how many are not, engaged in one or another of the modes of continuing education is a necessary part of any rational inquiry into the extent to which needs are being met.

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[4] Investment for Tomorrow (previously cited in Chapter I), p. 55.

An additional use of recorded information is for research in areas such as personnel and productivity. One laboratory reported a study which showed that research personnel who had been supported in reduced-time and educational leave programs had longer subsequent service with the company after receipt of the degree than did the average salaried person in that company. Here is documentary evidence that such programs are paying off in at least one respect (i. e., retention of employees for whom funds have been expended).

Two summary sets of facts may be, in spite of their sparsity, of some interest:

> 1. Comparable figures on total work force (professional and non-professional) and total educational expenditures (continuing education and other educational activities) were available in five laboratories (two government, three industrial). Dividing the total expenditures by the total work force yields the expenditure per employee. For the five laboratories, these figures are $101, $104, $216, $254, and $1,178. The average expenditure per employee for the five laboratories combined is $161. The average total expenditure per laboratory is $595,794.
>
> 2. Nine laboratories (three government and six industrial) report comparable figures on tuition refunds paid to individuals or to universities for courses taken in 1966 or 1967. The tuition refund expenditure per employee ranges from a low of $19 to a high of $102. Three laboratories spend $31 or less per employee; three between $47 and $49; one, $71; and two, $100 and $102. The average for all nine combined is $55. The average total tuition-refund expenditure per laboratory is $61,363. These figures reflect the differences in tuition costs in different schools, and the two highest per-employee figures also reflect subsidies to the universities providing credit courses on the laboratory site.

Even these limited figures indicate a rather substantial investment in educational activities by both industry and government. (The figures given above were compared for industry and government and do not indicate that there is any appreciable difference between industry and government employers in amounts spent.) If figures were available just for the professional scientist and engineer, undoubtedly the averages would be higher per employee. In one laboratory where we could obtain them, the average expenditure per professional is $270 for graduate studies, other tuition refunds, and educational and sabbatical leaves. In this laboratory, 16 percent of the total professional research people participated in all of these activities combined during 1967. Thus, if the programs were to be extended to additional people, the costs could quite possibly become prohibitive.

In spite of very limited data on actual expenditure, the interviews with top managers indicate that R&D employers expect to pay all of the costs of some modes and at least part of the costs of others. Generally, R&D employers in this group of 17 provide the financial backing for any activity taking place on their own premises, such as in-lab courses, lectures, and other types of in-house training. These are activities which the employer provides because management wants individuals exposed to this training; therefore, employers pay for it. R&D employer policies vary more with respect to tuition refunds for university or college credit courses. Some employers have adopted the practice of paying all tuition for work-related courses, while others pay anywhere from 50 to 90 percent. These latter employers adopt their policy on the assumption that the individual also has an obligation to invest money, as well as time and energy, in his education. With reference to other modes of education off the premises, all but one of these R&D employers expect to pay the costs of attending professional society and other meetings, outside short courses, and leaves of absence for sabbatical or other study purposes providing the employer wants the employee to engage in these. In all the laboratories, the initiative for expressing a need is largely left to the individual, and the employer sets procedures for reviewing and approving requests for time and money to engage in these modes. To the extent employers foot the bill for continuing education off the premises, they also retain the right to set the limits and conditions which govern who goes where and when. The assumption underlying management philosophy is that paying the costs removes one major obstacle to engaging in these particular activities and opens the door to positive forms of stimulation to motivate the individual to action. At the same time, paying the costs gives management the control over productive time "lost" in these activities and over selecting or approving, on an individual basis, the use of these activities.

Management Degree-Seeking Objectives and Programs

In about half of the 17 laboratories, there is as much or more emphasis on degree-seeking programs for professional R&D employees as on activities here considered continuing education. In these laboratories, then, continuing education takes place in a different context than in laboratories where the stress is greatest on continuing education per se. Six industrial and two government laboratories sponsor reduced-time programs to enable employees to seek advanced degrees. In these programs, employees work part-time (half or three-quarters) and go to school part-time. Two of the same six industrial laboratories and seven of the eight government[5] laboratories support full-time educational leaves of absence also to enable employees to seek advanced degrees. The objectives of these programs are:

1. To increase the number of highly qualified research people whose training is directed to employers' needs.
2. To enhance the loyalty of scientific and engineering personnel and retain them for the future.
3. To aid in recruiting bright young men who have completed their bachelor's degree but lack the resources to continue working for a graduate degree on a full-time basis.

Degree-Seeking and Continuing Education

Managements in at least two of the laboratories have become active in supporting degree-seeking programs partly because in a tight labor market they cannot hire persons with degrees and course-work qualifications they want in the laboratory. The impact which these degree-seeking programs have on continuing education is very important. These degree programs create anxiety in those who are not seeking advanced degrees and cause them to wonder if their time is not better spent in the long run in acquiring the credentials of knowledge than in the pursuit of just that knowledge which they need to keep up to date and to extend their work to new horizons. One top manager expressed the prevailing opinion on this point as follows:

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[5] Federal regulations prohibit support of full-time study for the sole purpose of obtaining a degree; the degree itself must be considered essential to the laboratory's mission.

> Our stress on recruitment of Ph. D. candidates for research and advanced development has helped create the impression that one must have a formal doctorate to compete in R&D programs. This atmosphere has undoubtedly had a beneficial influence on numbers of our young and able staff who have decided to complete their formal education early in their careers. Unfortunately, the same pressure has spilled over to longer service employees for whom the formal Ph. D. requirements are no longer an effective learning procedure. Those master's level employees who are doing work fully equivalent to their fellow Ph. D. s have two uncomfortable choices. They can stay where they are, feeling somewhat uncomfortable and out of place. Or they can make the considerable effort and sacrifices required to meet the formal requisites for a doctorate. In the two cases it is natural that the employee looks to the company for support since we give every indication we believe education is desirable. It is my personal opinion that there comes a time in work experience past which the added value of a Ph. D. cannot be measured in terms of added productivity.
>
> Ph. D., Physics, Top Management

The same point is made in the interviews with a significant number of scientists and engineers (most of whom are over age 35). These people say that they already have the necessary theory and background for their research. A degree program would not teach them enough additional knowledge to make worthwhile the effort of meeting formal degree requirements. Rather, these men say, it is better for them to concentrate on those course-work and other continuing education activities which increase their competence on the job they have to do. It takes a considerable amount of psychological security, and security stemming from employer reassurance, to do this rather than seek a degree in a work environment in which degree-seeking is being emphasized. Employers who sponsor degree-seeking programs, then, should also take steps to reassure those employees who do not seek degrees that it is job performance, not the possession of an advanced degree, which is critical to their careers.

Nevertheless, the correlation data from the questionnaire support the prevailing impression that those persons who possess advanced degrees, particularly the Ph. D., tend, on the average, to be better paid, have more autonomy and responsibility at work, and to achieve more promotions (as well as more publications) than those who do not have them. Furthermore, the correlations resulting from the questionnaire reveal no relationship between promotions (either the total received on all jobs or the average number per job) and engaging in continuing education activities. Thus, on the average, job mobility is neither enhanced nor retarded by engaging in continuing education, but having an advanced degree is related to the number of promotions, and the number of publications and other measures of output included in the questionnaire. Needless to say, both salary gains and age are related to the promotion and achievement variables in such a way as to support this interpretation.

These data are sufficient evidence to suggest that the whole area of the relationship between advanced degree-seeking and continuing education needs more detailed and thorough study than it has yet received. It is very possible that, at present, degree-seeking ultimately results in greater rewards for the individual than does continuing education for more practical purposes. An unanswerable question is which -- degrees or continuing education -- result in greater benefits to the laboratory mission?

Summary and Conclusions

The three key points in top laboratory management philosophy of continuing education are: management accepts the responsibility to provide at least some opportunities for scientists and engineers in the R&D work force; management expects R&D employees to take advantage of these and other opportunities to keep themselves up to date, particularly in their own fields of specialization; and, finally, management accepts only limited responsibility for motivating the individual. Managements which provide opportunities for continuing education believe that those who do not take advantage of them are not "worth" attempting to salvage. The initiative is left to the individual.

Employer programs, on the whole, provide some alternatives to scientists and engineers seeking continuing education activities. All but one of these 17 laboratories use two or more modes of continuing education to assist R&D people to keep up to date. However, not all the modes which are sponsored in any one laboratory are universally available to every R&D professional who might want to use them. Management places various restrictions on these activities which are elaborated in detail in Chapters V and VI.

Employer programs consist essentially of various combinations of six different modes of continuing education as reported in Table III-1. Each employer supporting any form of continuing education must determine his own set of needs and objectives and then the combination of modes which most effectively supplies these needs. For the most part, employers rely most heavily on paying expenses to professional meetings, tuition refunds, and in-lab lectures to keep people up to date. Outside short intensive courses, in-lab courses, and sabbatical leaves are less uniformly available.

Among these 17 laboratories, there is a considerable investment being made in educational activities, but evidence is inadequate to determine exactly how much is being spent on any one of the modes, or what the average per capita per professional is in most of these laboratories.

We recommend that managements institute an accurate record-keeping system which will reflect the numbers and types of personnel engaged in any one of the employer-sponsored modes of continuing education. Management should take additional steps beyond this measure and assess these modes in terms of their value to the laboratory and the individual. Without such basic personal research, management is not able to effectively assess whether continuing education pays off.

We also recommend that laboratories which do not now have such a committee should establish a professional development committee whose function is to initiate, review, and to recommend action programs in continuing education.

For future research, we also recommend that the area of interrelationship between degree-seeking programs and continuing education programs be investigated to determine the impact of one on the other and to investigate the priorities which should be established for each within any one employer's total education needs.

CHAPTER IV

THE INDIVIDUAL'S PERSPECTIVES AND PARTICIPATION IN CONTINUING EDUCATION

Chapter III presented general findings on employer policy based on interviews and documents obtained from the top managements of these 17 laboratories. This chapter presents the results of the interviews and questionnaire about how individuals view their needs in continuing education, and the scope and extent of their participation. In the three following chapters, each of the modes of continuing education is discussed in greater detail, both as to employer policy and practice and as to the individual's participation in, and appraisal of, each.

The Researchers' View of Continuing Education and Technological Obsolescence

Continuing education emerges from the personal interviews with scientists and engineers as a much more complex and dynamic process than is generally recognized or implied in the existing literature on the subject. It is a counterpoint of different modes of education, some of which are more suited for certain needs and purposes than others. Opportunities for using modes vary, and their availability to the individual depends on both his prior training and present state of knowledge and skill, as well as on the policies and practices of his employer. The individual scientist or engineer must choose modes of continuing education which best fit his situation at any given time. Periodically he is faced with the necessity to reassess his needs and re-examine the educational alternatives available to him because of changing circumstances in his job and/or his personal goals and interests. For example:

> I feel a research scientist is always having to learn new things in order to keep up and to do research. A research scientist must do this! What I've done is to read as widely in the chemical literature as possible and to go to meetings which will broaden my knowledge into something I don't know before. And to take courses in a technique or something. If I couldn't find a course, I'd do it on my own.
>
> Ph.D., Organic Chemistry, age 40

> I left school a long time ago and at a particular point when my particular discipline, organic chemistry, was just about to make a significant break with the past. While I have read books and kept up with the general articles and tried to learn the new approaches from review articles, I still feel that sooner or later I would like to review my discipline in an academic environment. At this stage, the people in college are already getting theoretical material that wasn't known in my day. While I feel I am reasonably well on top of it, I don't have the vocabulary. I don't think in the same terms, either in the oral or in the mental vocabulary.
> Ph.D., Organic Chemistry, age 40, Supervisor

Continuing education also emerges from these interviews as a process with a decidedly more positive orientation and function than that of overcoming technological obsolescence. It became clear very early in the interviewing that the term "technological obsolescence" conveys broad, non-specific, and very negative connotations to research people. While they fear falling behind and getting out of date, they are more concerned with keeping up to date and extending their careers in research by continuously learning something new and by solving new problems. As two men put it:

> It's practically impossible for a researcher to get by for long without at least self-education. Even the business of reading the current literature is self-education.
> Ph.D., Microbiology, age 45, Supervisor

> In the electronics business, I can't imagine a man becoming obsolete. He must keep learning because his problems are always new. This is particularly true in R&D organizations where you only build one of a kind. Each problem is new and unique, and there are new things to learn. In some areas, the technology may be changing, but the basic ideas are the same.
> Bachelor's, Engineering Physics, age 30

This is the converse of technological obsolescence. It is keeping up to date with what they need to know in order to work on the frontiers of knowledge. It is this orientation research people use when talking about themselves. Few will admit to being technologically obsolescent; many will concede they are not completely up to date with all that interests them; and most admit that keeping up to date is a problem for them. However, research people contend that they are sufficiently up to date to work in their own field of specialization.

> You can keep up with your own specialty, but neighboring specialties are hard to keep on top of. It can be handled in terms of reading... or lectures which cover the field, but not getting into the details.
> Ph.D., Physics/Mathematics, age 48

To researchers, obsolescence is something that happens to people who move out of research. They maintain that a research person cannot be obsolescent in his own field and work on the frontiers of knowledge. Researchers say those who do not do a good job of keeping up to date but who remain employed in R&D laboratories are assigned to jobs for which they are fully competent, doing essential but routine work which is not on the frontiers of knowledge.[1]

> A lot of times supervisors will tolerate a nine to five type individual... This means that very brilliant men can do a decent job, but they are not realizing their full potential as scientists. But they may be happy in this.
> Ph.D., Nuclear Physics, age 52, Supervisor

Supervisors report their needs in continuing education somewhat differently in terms of depth and breadth than do non-supervisors. The higher-level supervisors interviewed do not feel a need to be right on top of ongoing work. They say their need is to be aware of, and up to date with, broad general movements and emerging directions in a wide range of fields that touch on the work of their subordinates. They can be uninformed about the details of research and technology, particularly experimental results. They say they must bring to bear their experience, judgment, and knowledge in interpreting the broad trends in research in assisting, clarifying, and guiding the work of subordinates. But they do not tell subordinates how to go about their work. This comment is fairly typical:

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[1] On the basis of a combination of responses to questions in our questionnaire and their intercorrelations, we estimate that about ten to 20 percent of our people fit this category of routine R&D professional worker. Most are non-Ph.D.'s, and more of them are found in the industrial laboratories than in government. Since our sample is neither random nor representative, these figures cannot be extrapolated to other laboratories. However, the inclusion of this type of R&D worker in this study ensures that we have covered the lower part of the range of motivation and interest in whatever deductions we make from the data. At the same time, the presence of these individuals in our sample affects the percents and the intercorrelations in the statistical data, hopefully giving a realistic picture of actual involvement in continuing education activities.

On the other hand, the data presented in Chapter VI on sabbaticals indicates that less than two percent of the work force is supported on sabbatical leaves with pay. Yet the sample contains 29 persons, or approximately five percent, who have been on sabbatical leave. This suggests that the sample contains some bias in the direction of participation rather than non-participation in continuing education. Whether the effects of this are offset by the presence in the sample of ten to 20 percent of "unmotivated" or routine R&D professionals is unknown. Since we do not apply our quantitative findings to a universe larger than our sample, the effects of a lack of representativeness, if any, are minimized.

> I was raised to believe if you're a professional, you have to keep yourself up to date. When I was working in the lab, I looked for anything I could use relevant to my work. Then when I was in charge of a group, my interests broadened to what the group members were working on. Now, the job I have, I have to keep up with the whole lab. I look for what I can recognize as a new field opening up. New discoveries. There is a vast mass in the organic chemistry literature which is just compounds. But some of the literature is extensions into new fields. (Do you have more or less time now for doing this?) Less. It's not recognized as a legitimate function for someone not at the bench. I spend more time on it at home, not less time doing it. It gets to be more and more difficult...I found a few years ago I had to expand and familiarize myself with all sorts of things I wouldn't have had to know if I had stayed at the bench.
>
> Ph.D., Organic Chemistry, age 51, Supervisor

Lower-level supervisors, who are closer to the day-to-day research and even usually involved in it, must keep up to date more in depth and less widely.

In the concept of keeping up to date, research people include as mandatory keeping up to date in the allied fields which bear directly on the problems they are working on. A research career is dynamic in the sense that the solution of a problem may open up a range of new problems to be solved, or the solution of a problem frees the researcher to change assignments and pursue another. In either case, as his career evolves and the individual moves from one phase of his work into another, he acquires interests and needs for knowledge in allied and neighboring fields pertaining to his specialty or specialties. Some of these relevant fields may not even be part of his discipline of original training. As one medical doctor put it:

> When I started in medicine, I didn't realize that statistical analysis was going to play as great a role. So I have to continue studying not only in medicine but in these now allied fields. Electronic devices are also important and require more education for me. So I feel continuing education is extremely important at least in the research I am presently

> engaged in....I think I will be required to continually educate myself not only in my own area but in those areas which are becoming allied in very unusual ways, particularly in the space business.
>
> M.D., Space Medicine, age 29

A mathematician turned engineer, also in the space business, has a similar problem:

> It's a "new problem every day" sort of world, all within a few broad disciplines. Problems are not static... You have to stay current with technology, you can't expect to find solutions in textbooks. You have to look at design and fabrication as well as materials. You must also stay reasonably current with the techniques of building things in whatever form. You have to stay reasonably current with environments in which equipment performs, so you stay up to date with simulation environments, too.
>
> B.S., Mathematics, age 39, Supervisor

Thus, continuing education for these people is something more than keeping up with the evolution of a unified discipline; very often the acquisition of knowledge, newly developed or long-established, from many disciplines is essential to the performance of their jobs. This is one instance of diversification (to use the Goals Committee term) which the research people of this study regard as a natural function of continuing education.

At least two levels of being up to date can be distinguished: the field of specialization, and the allied or adjacent fields which bear on it. These require different degrees of being up to date. The space-medicine scientist above expresses a need to acquire additional tools not a part of his original training as well to keep up to date in space medicine. The mathematician turned engineer is keeping up to date in a field of research in engineering which did not exist at the time of his original training, and for which there may not even yet be available much university training coherently organized into a discipline. This man is struggling to keep up with an emerging field just being put together. Both require learning and keeping up with a variety of different parts of relevant allied fields in order to do their work.

In general, research people make a distinction between their own field and allied fields. The scientists and engineers say that being up to date in their own field of specialization in considerable detail is necessary to work on the frontiers of knowledge. In addition, they must be alert to new developments in allied and adjacent fields which affect their work but not as up to date as in their own field of specialization. It is desirable to recognize this latter state as a second level of being up to date and not as a form of obsolescence. If this second level is considered a degree of obsolescence, then the goals set for being up to date are unrealistic and beyond the capability of most research people. Rather, research people indicate they can "afford" to be behind the latest developments in allied fields *providing they keep themselves informed enough to look into them when these developments become relevant to their work*.

This point has been stated in other ways in the literature. The SPEEA developed a program for updating its member engineers and, as part of its rationale, quoted John Shive of Bell Laboratories:[2]

> The field of communications is dynamic and the engineer seeking a rewarding career in this field *must develop both the specialist's depth and the generalist's perspective*. He must have enough specific knowledge and skill to bring to bear in his work the most effective modern techniques. *Yet, he must be flexible enough to move in the new directions which a dynamic technology is continually unfolding*.

This is essentially what people working on the frontiers of knowledge are striving for in their continuing education objectives, because it maximizes their flexibility and ensures their continuation in research as knowledge changes and develops.

When scientists and engineers talk about keeping up to date, they often say, and always intend to mean, keeping up to date with the state of the art or arts. The term "state of the art" is commonly used by both scientists and engineers to refer to the very latest and most up-to-date thinking and practices in research and development. As such, the "state of the art" refers to the theories, tools, and applications which are being used today by the leading scientists and engineers throughout the world. While the state of the art necessarily includes much of the rich heritage of the past, as used by the scientists and engineers who were interviewed it specifically *excludes* theories and practices which have become outmoded and superceded by those that are more efficient and effective.

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[2] *SPEEA Plan: Continuing Engineering Education* (previously cited in Chapter I), p. 8. This quotation is taken from a brochure on continuing education by John N. Shive, who is director of the Bell Telephone Laboratories Education and Training Center.

The Researchers' Objectives in Continuing Education

For every continuing education activity reported, each scientist and engineer was also asked why he engaged in it and what was his purpose at that particular time. On the basis of these responses, we can distinguish a list of different objectives fairly similar to those reported in the literature:[3]

A. Overcoming Obsolescence -- Catching Up

1. Refresher purposes -- to become familiar with material once learned. This is most commonly the fundamentals of a scientific or engineering specialty or mathematics.
2. Updating -- to acquire a knowledge of new developments since prior training in the fields in which the individual is expected to be competent.

B. Preventing Obsolescence -- Keeping up to Date

1. To maintain competence in using current concepts, theories, practices, and points of view in the individual's own fields of specialization and in allied or adjacent fields which bear on them. This is more commonly and succinctly expressed as keeping up to date with the state of the art.
2. To know and understand what others in the same field are working on, that is, which problems they are trying to solve and what approaches to solution they are taking.
3. The other purpose of being up to date with the state of the art is negative:
   a) to avoid duplicating work others have already completed.
   b) to avoid blind alleys and other activities already proven or judged to be fruitless by others.

C. Diversification -- Acquiring Additional Competence

1. Upgrading professional competence -- to acquire competence:
   a) in techniques and applications of knowledge from allied fields in order to become more proficient in own specialty.
   b) at a broader or more specialized level in own fields or specialties.

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[3] For example, see references previously cited in Chapter I: (1) Interim Report of the "Goals" Committee, p. 41; (2) Education in Industry, p. 9; (3) Mueller, "The Role of the Technical Society in Continuing Engineering Studies," pp. 2-3.

2. Developing new areas of specialization -- to acquire competence:
    a) in newly emerging fields of research related to own field.
    b) in additional areas of specialization because a change of assignments requires knowledge not previously needed on prior assignments.
    c) in additional areas of specialization in own or allied field or discipline to enhance flexibility, breadth, and opportunities in own research.

The above list of objectives can also be seen as a list of needs, that is, the kinds of activities a research person must engage in if he is to extend and prolong his career in research.[4] Overcoming obsolescence, preventing it, and diversification into new fields are a necessary part of his career goals if he continues to work on the frontiers of knowledge. However, it can be misleading to think about continuing education in these static, categorical terms.

It should always be kept in mind that any continuing education activity, any need, any opportunity is relative to a particular area of knowledge needed on the job and not to the totality of prior education. It is entirely possible for a person to be obsolescent in some areas, keeping current in others, and diversifying into still others all more or less at the same time. What is critical is keeping up to date on his own specialty or specialties and, for the future, being in a ready state to move into something else if present specialties become outmoded by advancing knowledge. In this connection, the average R&D professional does not become concerned about refreshing his prior training -- that is, restudying materials once learned -- until his work assignments calls for the specific skills or knowledge. Thus, refreshing needs to be seen in the context in which it is useful; it is largely irrelevant until needed on the job and is not an activity to be desired for its own sake.

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[4] Recall that this study does not include non-technical educational activities. If it had, there would be a category of "maturing a person's education" to use the Goals Committee term. The subject areas of this type consist of communication skills (rapid reading, writing, languages, and public speaking), supervisory skills (human relations, motivation, and planning), and management training. All of these are studied to enhance capabilities outside the technical area. These are the same subjects reported in other studies as being most frequent in the non-technical area.

Employee Participation in Continuing Education

There are a number of approaches to assessing employee participation in continuing education activities. This section reports some quantified results obtained from the continuing education questionnaire completed by 394 scientists and engineers. Each individual indicated whether he had used a given educational activity in the past two years (1965-1966). The results are summarized in Table IV-1 for the six employer-sponsored modes identified as components of employer programs.

Table IV-1 indicates the following differences between scientists and engineers:

1. More scientists than engineers attend professional meetings and go on educational leaves of absence with pay.
2. More engineers than scientists attend short intensive courses (one or two weeks in length).
3. More scientists than engineers attend in-lab lectures or seminars.

The table also indicates a difference between industry and government employment:

4. More government than industry professionals go on educational leaves of absence with pay.

These uniformities suggest that:

a) Educational leaves of absence with pay are more characteristic of government scientists than of either engineers in government or scientists and engineers in industry.

b) More scientists than engineers engage in modes involving interaction with colleagues, that is, attending professional meetings and in-lab lectures or seminars.

By inference, then, scientists tend to incorporate contacts with colleagues and universities in their continuing education activities to a greater extent than do engineers. Engineers, on the other hand, more narrowly define their continuing education needs by emphasizing course work more than modes involving interaction with colleagues. However, it is clear that at least half the engineers in R&D are like scientists in attending professional meetings, and more than half in attending in-lab lectures or seminars. Thus, the picture is one of trends or tendencies rather than one of clear-cut distinctions between scientists and engineers in R&D. In Chapter VIII, additional data are presented

TABLE IV-1

COMPARISON OF SCIENTISTS VS. ENGINEERS AND INDUSTRY VS. GOVERNMENT BY PERCENT OF PARTICIPATION IN EDUCATIONAL ACTIVITIES USED IN THE PAST TWO YEARS

ACTIVITY REPORTED USED	Scientists N=231 %	Engineers N=163 %	Industry N=213 %	Government N=181 %	Total N=394 %
Professional Meetings	75	49	62	67	64
University Credit Courses	28	31	25	34	29
Short Intensive Courses	17	28	21	23	22
Educational Leaves of Absence with Pay	10	4	2	14	8
In-Lab Formal Courses (Non-Credit)	35	33	35	33	34
In-Lab Lectures or Seminars	87	66	78	80	78

which suggest it is the more development-oriented, as compared to research-oriented engineers, in R&D who most utilize course work and least utilize modes involving contacts with colleagues.

Table IV-2 compares scientists with engineers on the number of educational activities reported used in the past two years.[5] This table shows the number of different types of modes used by scientists and engineers, and supplements Table IV-1 just discussed. The distribution of participation is quite different for scientists and engineers:

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[5] The table is based on nine activities given in the questionnaire (question #3) which listed the six employer-sponsored modes shown in Table IV-1 plus "reading the scientific and technical literature" (which is later defined as a self-teaching mode), and two other activities, "workshops on specific subjects" and "discussion with outside consultants" (both of which turn out to be largely irrelevant, since workshops are confused with in-lab courses and outside non-credit courses, and discussions with consultants are not seen as directly related to continuing education). In order to report these data, we must tabulate on the basis of nine activities.

> 1. Fifteen percent of the scientists report using none, one or two of the nine activities in the past two years, as compared to 37 percent of the engineers.
>
> 2. Seventy-nine percent of the scientists report using three to six of these nine activities, as compared to 59 percent of the engineers.

TABLE IV-2

COMPARISON OF SCIENTISTS AND ENGINEERS ON NUMBER OF EDUCATIONAL ACTIVITIES REPORTED USED IN PAST TWO YEARS

NUMBER OF ACTIVITIES REPORTED USED	Scientists N=231 %	Engineers N=163 %
None	3	7
One	6	10
Two	6	20
Three	17	15
Four	26	21
Five	21	15
Six	15	8
Seven	4	2
Eight	1	1
Nine	*	0
TOTAL	99**	99**

* Less than 0.5%

** Percents do not add to 100 because of loss in rounding.

Thus, in general, R&D scientists are more active in educational activities than are R&D engineers. However, more than half of each use multiple modes of continuing education to keep themselves up to date. The point of concern is that over one-third of the engineers utilize none, one, or two modes, suggesting again a more narrow focus in continuing education than is characteristic of scientists in general.

TABLE IV-3

IMPORTANCE OF MODES: EDUCATIONAL ACTIVITIES AS FIRST OR SECOND IN IMPORTANCE IN KEEPING SELF UP TO DATE

EDUCATIONAL ACTIVITY	Percent Who Use Activity* N=394 %	Percent of Users Ranking Activity First or Second %
Reading the Scientific & Technical Literature	98	85
Professional Meetings	77	44
University Credit Courses	36	44
Short Intensive Courses	22	41
Educational Leaves of Absence with Pay	14	21
In-Lab Formal Courses (Non-Credit)	40	20
In-Lab Lectures or Seminars	81	28

* The figures given in this column do not correspond with those given in the totals column of Table IV-1 because more people rank these activities in question #3 than report using them in question #2 on which Table IV-1 is based. This represents an error in following directions on the questionnaire.

The preceding results reflect the degree of actual participation in employer-sponsored educational activities. Table IV-3 is designed to show how important these activities are to the individuals using them. Table IV-3 includes reading in the list of activities as well as the employer-sponsored modes of activities. Table IV-3 yields two pieces of information. The first column indicates how many people claim to have used the activity in the past two years; the second column indicates how important they consider it to be in keeping them up to date. (The second column combines first and second ranks because two-thirds place reading as most important, that is, in the first rank.)

On the basis of Table IV-3, reading the scientific and technical literature is clearly the most important of the activities listed in keeping people up to date. Not only is it the most used, but it is the most important to almost everyone who uses it. Several other observations about the data in Table IV-3 are of interest in understanding the more detailed examination of these modes presented in Chapters V and VI.

More than twice as many people attend professional meetings than attend university credit courses, yet 44 percent of users rank each of these modes as first or second in importance in keeping themselves up to date. These modes serve different functions: professional meetings keep people up to date by keeping them in contact with other researchers in their own field so that they know what is going on and can anticipate future developments of consequence to their work. University credit courses are taken primarily for diversification purposes and are considered by professionals to be the best way of learning the fundamentals of a subject in a systematic orderly way with emphasis on the theory of the subject matter. As previously shown, professional meetings are used by more scientists than engineers, but about equal numbers of both take university credit courses.

Short intensive courses are taken by 22 percent of the sample, but almost as large a percent regard them as important as do users of either professional meetings and/or university credit courses. Consequently, these three modes are considered to be the primary modes supplementing reading, which is the basic and most important mode in keeping up to date.

Substantial numbers of people attend in-lab lectures or seminars, but relatively few regard them as their most important mode of keeping themselves up to date. Considering their widespread use, this fact may be somewhat disturbing to management sponsors of these lectures. However, the picture is actually more favorable than as presented here and is described in more detail in Chapter VI.

Turning now to the question of what kinds of people tend, in general, to use these different activities, the following paragraphs describe the type of R&D person who uses certain modes as compared with others.[6]

Those who attend professional meetings and those who take educational leaves of absence with pay tend to be Ph. D. s and masters who are scientists, work in small groups as independent researchers or supervise large groups of other people, and report a high level of publications, work-related reports, and freedom to set their own goals. These people could be called the "elite" R&D professionals, since they have all of the status and prestige symbols and claim to be productive at a high level.

Those who take university credit courses and short intensive courses tend to be bachelors and masters, who are less well paid, less productive of publications and reports than the elite, and who report little autonomy or independence in setting their own research goals. There are differences between those taking credit courses and those taking non-credit courses. The credit course people tend to be younger and to report relatively less job satisfaction than others. This suggests they are young men seeking to achieve a better position in research through education, but not necessarily seeking advanced degrees. Non-credit people tend to rank short courses as of most importance in keeping them up to date, and age is unrelated to taking short courses. This suggests that these people have more restricted and short-range goals in continuing education than others do.

Those who engage primarily in in-lab course work (non-credit) tend to be relatively young, without Ph.D.s, and have received few promotions. They are heavy readers and users of the library. These people also report only modest contributions from themselves to the literature, to the employer organization, and to science in general. This suggests they are without much contact with the wider world of science and engineering outside their own laboratory.

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[6] The following paragraphs are based on the results of a multivariate analysis. The questionnaire contained a total of 201 variables, or different items of information reported by the individual completing it. Each of these variables can be correlated with every other to determine which variables have significant degrees of association with each other, both positive or negative. There are 20,100 correlations in a matrix of 201 variables. We do not burden the reader with these data, but present only our interpretation of them in these paragraphs and elsewhere in this report.

In-lab lectures and seminars are attended by such a large and diverse number of people that no clear profile emerged in the multivariate analysis.

All of the results presented in Tables IV-1 through IV-3 are conditioned by the availability of these activities from laboratory to laboratory. Availability is conditioned by management policy and practice, job pressures and demands, individual interest and motivation, and supervisory encouragement or the lack of it. These "conditions" create a rather complicated set of circumstances in which continuing education takes place. The chapters which follow attempt to spell out these conditions in more detail.

Expressed Needs in Continuing Education

In addition to asking the scientists and engineers in the questionnaire sample what they did and what order of importance it had in keeping them up to date, they were also asked what else they thought was needed in their laboratory in continuing education activities for themselves. The responses are classified and presented in Table IV-4.

Almost one-fourth of the scientists and engineers say that nothing else is needed, that existing opportunities for continuing education are adequate, and many add that it is up to the individual to take advantage of those that are already there. For example:

> Since the government is very liberal in providing resources for continuing education opportunities, limitations rest only with the interest of the individuals concerned.
>
> Master's, Physics, age 42

Among the needs that are cited, the need for more in-lab courses, in-lab lectures, and paid educational leaves are most frequently listed. All the other needs were cited by only a small number relative to those who say opportunities are adequate. A more detailed analysis of these needs as expressed by these people is given where appropriate with reference to the individual mode in Chapters V and VI.

TABLE IV-4

EXPRESSED NEEDS IN CONTINUING EDUCATION

NEED CITED	Percent N=394 %
Existing Programs Are Adequate	23
In-Lab Courses	17
In-Lab Lectures	12
Paid Educational Leaves	11
Supervisory Encouragement	8
Outside Short Intensive Courses	6
University Credit Courses	6
Expenses to Professional Meetings	5
Tuition Refunds for Non-Credit Courses	4
Workshops on Specific Topics	4
On-the-Job Reading Time	4
Improved University Programs	4
Communications Exchanges of Information within Laboratory	4

It is important to note two other facts in Table IV-4. One is that no "new" or radically different educational activities are listed which do not already exist in at least some laboratories. The other is that eight percent mention supervisory encouragement of continuing education as a need. Supervisory encouragement is further discussed in Chapter VIII.

Summary and Conclusions

Continuing education for R&D scientists and engineers is a dynamic process dependent on the individual, his background and present knowledge, interest and motivation, and the opportunities which are available to him at any given time through his employer and others. Although overcoming technological obsolescence is recognized as something which can be a problem for some people, most R&D people stress the function of continuing education as a means of keeping up to date. They see keeping up to date as a positive and continuous activity required for working in research; it also prevents technological obsolescence. Both scientists and engineers stress extending their knowledge into new fields as it becomes available or, if it is not new knowledge, at least acquiring what is needed on the job. These people claim that an individual cannot remain working on the frontiers of knowledge and become obsolescent in his own specialty or specialties. He must also remain up to date in allied or adjacent fields, at least to the extent of being able to utilize them when they become relevant to his work.

The term "technological obsolescence" is an abstract one, which may be inappropriate in a variety of ways and which, therefore, justifiably draws a good deal of resistance and resentment from R&D scientists and engineers. The phrase might indeed be a suitable description for an inert or totally static structure -- such as an instrument or even a whole laboratory or factory. The term itself implies an evaluation of the technologically-obsolescent thing (or process) from a producing (or mechanical) point of view. The phrase does not sit well with humans in any case, and it is peculiarly unsuitable to describing thinking, working, knowing, and creating activities and people. Scientists and engineers can readily conceive of themselves or their colleagues as being deficient or having a deficiency in some new area or in some developments in their field or tools. But it is small wonder that the R&D professionals in this sample find "technological obsolescence" a remote and rather insulting term and are unable to relate it to their felt needs for new information, for access to the recently-emerging knowledges and technologies which they must use in their work.

The data presented in this chapter show that R&D scientists, on the average, are more active in continuing education and utilize a greater number of modes than R&D engineers, although at least half of the engineers are equally as active as scientists. Reading the scientific and technical literature is the most used and most important method of keeping up to date. Three other modes seem of primary importance in supplementing reading. Professional meetings are more used by scientists than engineers, and about 44 percent of those who use them regard them as of first or second importance in keeping up to date. About equal numbers of scientists and engineers take university credit courses, mainly for diversification, and 44 percent regard these as important in keeping up to date. Short intensive courses are more used by engineers than scientists, and 40 percent of the users regard them as important in keeping up to date.

CHAPTER V

COURSE WORK MODES OF CONTINUING EDUCATION

This chapter deals with three types of course work used for continuing education purposes: university credit courses; in-lab, non-credit courses; and outside, non-credit short intensive courses. Each mode is discussed vis-a-vis the laboratory policy and the extent of participation. This discussion is followed by a summary of the pros and cons of these course work modes which were brought out in the interviews and in the written comments on the questionnaire.

University Credit Courses

University credit courses are defined as instruction offered by a university or college identical to that offered to full-time, degree-seeking students. The courses, because they can be used in degree programs, meet the requirements of academic standards. Students, whether or not they are seeking a degree, must meet admissions requirements before registering. Such courses assign grades based on examinations or other requirements as a measure of student performance.

Because university credit courses adhere to rigorous standards, they set the achievement level by which other course work modes are measured for their potential contribution to an individual's knowledge. Scientists and engineers often assess the effectiveness of other course work modes by comparing them to university credit courses.

University credit courses have inherent advantages and disadvantages for R&D scientific and engineering personnel who seek to use them for continuing education. The purpose of the first section is to examine their role in continuing education.

Laboratory Policies and Practices. All 17 laboratories have policies which encourage taking university credit courses. At the same time, managements generally discourage taking more than one or two courses per term; more than two are seen as interfering with the employee's performance on his job.

Encouragement takes a variety of tangible and intangible forms. The latter are manifested in:

1. The personal interest that supervisors or management convey to their subordinates in the form of advice as to what they consider suitable courses for advancement in responsibility or enlarged work assignments.
2. The prestige accorded those personnel with advanced training.
3. The freedom given to those with a record of accomplishment in education and work performance to choose their own approach and methods in solving a research problem.

Tuition refunds are the most tangible means of encouragement and the most widely and uniformly applied. All 17 laboratories have tuition-refund policies and practices. These are spelled out in written company policy and usually apply to all employees, not just those in research and development. Eleven reimburse all tuition or pay the university directly without going through the student; the remainder reimburse the student differing amounts, but in no case less than 50 percent of tuition.

Policies on tuition refunds, however, are all subject to qualifications. For example:

1. Fifteen of the laboratories require that a course must be work-related in order to qualify for tuition refund; however, this requirement is usually broadly interpreted.
2. In the industrial laboratories, any course taken for a technical degree is likely to qualify.
3. In government laboratories, courses taken solely for degree purposes also qualify for tuition refunds, providing the degree itself is needed by the laboratory.
4. Fourteen of the 17 laboratories require that a grade be received for tuition refunds. In some laboratories, this means that a course must be completed and the grade submitted before the tuition is refunded. In effect, these 14 laboratories limit tuition refunds to credit courses, since many non-credit courses do not require grades.
5. Laboratory policy tends to be quite restrictive about time off to attend university credit courses (other than in reduced-time programs for degrees). Only one laboratory regularly permits its research personnel to come and go to university credit courses during normal working hours. It is located less than a ten-minute walk from either of two major universities with which it has extensive contacts quite apart from continuing education. Other laboratories permit time off to take a course in exceptional circumstances, but not as a general

rule. The reason given is that travel time to and from class equals or exceeds the time spent in class. A reason not usually stated so explicitly, but one which underlies the travel-time reason, is that the gain in the individual's knowledge does not offset the loss of so much of his productive working time.

On the other hand, when university credit courses are available evenings and weekends, employers encourage personnel to use them by providing tuition refunds as well as the intangible forms of encouragement noted above.

Employers support employee enrollment in university credit courses for two reasons. First, the credit feature assures them that the course is taught by someone who presumably meets faculty standards and that the students meet required performance standards in competition with other students. Second, if university credit courses are available at convenient times in subjects needed or desired by research people, the laboratory need not seek out other opportunities for presenting these materials to its people.

Employee Use of Credit Courses. A total of 115, or 29 percent of the 394 questionnaire sample, report taking a university credit course in the two years prior to this study. Of these, half are degree-seeking students and half are not. This means that about 15 percent of the research people in this study have pursued university credit courses purely for continuing education purposes. Among the 115 taking university credit courses, scientists and engineers are about equally represented. Sixty-two (54 percent) are in government and 53 (46 percent) in industrial laboratories. There is a positive correlation with age and a negative correlation with having a Ph. D. and taking university credit courses. This means, as reported in Chapter IV, that younger men without Ph. D. s are the most typical users of university credit courses.

Advantages and Objectives of Taking Credit Courses. In discussing university credit courses for continuing education purposes, the research scientists and engineers emphasize the following two interrelated advantages:

1. University credit course work facilitates learning a subject systematically and logically. A university credit course is designed by the teacher to cover the subject matter in an orderly, comprehensive way that integrates it into a discipline and shows the student the logical steps from one principle to another. This results in more thorough, in-depth learning of a subject, because the student is required to take time to study, reflect, and work problems. The level of absorption of the material is thus higher than in some other modes, for

example, a short intensive course in which time to reflect and work problems is minimized.

2. *A university credit course imposes a greater discipline on the student than any other mode*. This discipline stems from the need to keep up with other members of the class, to complete homework, and to pass examinations. In this sense, a credit course provides an "outside" structure for the individual. That is, he does not have to impose it on himself by inner self-discipline as he must when reading and studying on his own.

The objective of taking university credit courses, as expressed in both interviews and written comments, is to diversify knowledge into new fields actually or potentially related to work. University credit courses are used to acquire the fundamentals of a subject so that the individual can apply them to his research problems. In the view of these people, a course should prepare him to carry on his investigations and to continue learning through self-teaching in its subject areas. One specific thing a course should do is to enable the student to read and understand the literature pertaining to the subject studied. Only infrequently do people report taking a university credit course for refresher purposes, that is, to restudy once familiar material.

On the other hand, university credit courses are not for keeping up with the state of the art on the frontiers of knowledge. The state of the art is said to be always in advance of the regular curricula -- the very latest developments and research results are not incorporated in university credit courses. A course cannot be developed until the state of the art at the frontiers of knowledge has produced enough results so that there is substantive material to be taught. Here is how two people summarize their thoughts on credit-course objectives:

> I would say the least effective way of keeping up to date is to go to a class at a neighboring university. That won't bring you up to date. If you want to learn about a subject, that's the best way.
> Ph.D., Mechanical Engineering, age 30

> I don't think taking course work in a university is a means of keeping yourself up to date. There aren't too many schools teaching courses at the frontiers. Most courses are background and basic. A few are taught from the literature and they are current. There are advanced courses but they're classic, not on the edge of current work. But there are some

which are based on the ideas of the past two or three years. These are a small proportion of the curriculum. In general, courses are to bring you to the point where you can pioneer new areas.

Master's, Physics, age 31

Barriers to Taking Credit Courses. University credit courses have several drawbacks for the active scientist and engineer. Classifying the difficulties as physical, social-psychological (which are somewhat interrelated), and academic, five barriers are identified in the interviews with scientists and engineers.

The physical barriers are:

1. Travel time -- the time it takes to drive to the nearby university, find a place to park, and then to drive home after class is the most frequently mentioned barrier to taking credit courses. These difficulties pose an obstacle to all but the highly motivated. If more than 30 minutes is needed to get to class, marginally motivated people lose interest; after 45 minutes even the strongly motivated express reservations. Illustrative of these feelings are the following comments:

If they offered transportation to the university, it would be helpful. It would be just enough to trigger me over the edge if I didn't have to drive in or out. Having to drive in rush hour is ghastly. So I don't attend now.

Master's, Electrical Engineering, age 33

As far as raw education, nothing else is needed here. The university nearby is one of the few schools in my field in the country. I do find it a pain not to be able to park. I normally do not go to the Wednesday evening colloquia because I can't park. The rest of the city you can go anywhere easily. It is not more inconvenient to fly in and out of town than to drive downtown.

Master's, Optics, age 32

2. Time schedules -- where university credit courses are scheduled primarily during the working day, they are largely unavailable for continuing education purposes. Some schools recognize this problem, and several offer some or all of their engineering or science curricula, below the Ph.D. level, during late afternoon and evening hours. One university schedules its entire master's program in the various fields of engineering between the hours of 7 and 9 A.M. Courses are attended by both regular degree, on-campus students and part-time employed students. The employed students arrange to arrive at work about 9:30 A.M. in order to attend these courses. This

program is unique and was developed by the University of Santa Clara specifically to accommodate engineers working full time.[1]

The social-psychological barriers are:

3. The effect on the individual's family life is a frequently perceived reason for not taking courses, particularly in the evening. Both study time and class time must be carved out of evenings and weekends, thereby reducing (or eliminating) companionship with wife and children. Highly personalized values determine how influential these family considerations are; enrolling for a night course is reported to be a mutual decision by husband and wife.

4. Another social-psychological barrier to taking university credit courses is cited primarily by older men, especially those having relatively high rank in their organization or among their colleagues. These people often fear they will publicly "fall on their face" in class, and many cannot even entertain the idea of such a shock. One man expressed his fears succinctly:

> (Why haven't you taken a course?) I think some hesitation about being in a class with really young people. It's a funny atmosphere to be back in school with kids twenty years younger. There may be some conscious and unconscious hesitation. You may be competent in some area, but in a particular subject they may have just had some prerequisite course in detail. It can be an embarrassing situation, particularly in a tough school....
>
> Master's, Meteorology, age 50

Feelings such as this create discomfort and also inhibit participation in class discussion.

The academic barrier is:

5. The problem of prerequisites is common to students who are not seeking a degree. An engineer or scientist may discover that a course he seeks to take entails prerequisites he does not have. In order to take the course, he must obtain a waiver. If this is obtained, he takes the course inadequately prepared, and consequently both risks poorer grades on examinations and needs more time to prepare and study. If he chooses to fulfill the prerequisites, he often believes he wastes time either by studying familiar material or by covering material irrelevant to his research needs.

Prerequisites in mathematics are mentioned as a major stumbling block, particularly by men who have been out of school some years and whose training was of the pre-space-age variety. These men point out that mathematics teaching and content have changed dramatically and drastically in recent years. Feeling rusty in the mathematics they once knew combines with the anticipated problems of learning the "new" mathematics to pose a most discouraging prospect. Mathematics faculty and department chairmen in the study reinforce this depressing view by stating that mathematics is a young man's subject and one requiring full-time study and attention.

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[1] The Santa Clara Plan -- An Evaluation of a Five Year Experiment in the Continuing Education of Engineers, Robert J. Parden, Dean, School of Engineering, University of Santa Clara, Santa Clara, California. (Mimeographed.)

Mathematics has a generalized importance since "new" math underlies, and is incorporated into, course work in a wide variety of engineering and scientific subjects. Without the ability to understand and utilize the mathematical tools integrated into these subjects, students are unable to fully comprehend and apply the course material. Consequently, without updating in mathematics, scientists and engineers are inhibited from updating and diversification through course work which is taught with a mathematical basis.

The only way that seems feasible to overcome this obsolescence is to undertake remedial course work designed specifically to prepare people in modern mathematics prior to taking courses which are mathematically based. As pointed out in Chapter I, several surveys indicate that mathematical subjects are the most frequently mentioned need for course work. The need for remedial course work in modern mathematics is fairly widespread and not limited to people in research.

Conclusion. Ways need to be found to overcome the physical and psychological barriers to taking university credit courses. Alternative forms of transportation might be used to overcome the driving and parking time problem faced by individuals going to and from class in their own car. (One laboratory instituted a car pool to one course which several of its research people wished to take.) Fulfilling prerequisites through in-lab instruction and particularly in mathematics through remedial instruction might give many of the older people the confidence they need to enroll in university credit courses. At least enabling them to enroll removes one excuse they now have for not taking such courses which they say would be good for them to take.

In-Lab, Non-Credit Courses

The literature mentions in-lab, non-credit courses fairly frequently but rarely describes their relative advantages and disadvantages. This section presents these pros and cons and discusses the unique and distinctive contribution this mode can make to continuing education.

Laboratory Policies and Programs. Seven of the 17 laboratories offer in-lab, non-credit courses on a regular annual basis. (The remaining laboratories may occasionally offer an in-lab course to meet a specific need; however, they do not rely on this mode to systematically provide continuing education opportunities to R&D personnel.) A total of 173 in-lab, non-credit courses offered in these seven laboratories in 1966-67 were examined through the course announcements or descriptions by responsible staff.

In-lab courses are offered for the following management reasons:

1. To provide instruction in subjects of interest at the intermediate level requiring only a bachelor's degree as prerequisite.
2. To provide refresher and updating instruction for those who have gotten rusty or out of date and need to review, and specifically for those who wish to take university credit courses for which they do not have the prerequisites and who are not confident of their ability to pass credit courses.
3. To provide instruction in advanced or specialized subjects of interest to the laboratory which are not available locally in universities.

Of the 173 courses, approximately ten are advanced beyond the intermediate level. Perhaps another ten are specifically remedial or for refresher and updating purposes only. The remainder, 88 percent, can be used for either of the first two purposes.

In general, employers prefer not to duplicate course work available in nearby universities. They reason that such duplication is a waste of laboratory resources (given that the nearby schools admit employees to take credit courses). Rather, employers seek to supplement what courses are readily available elsewhere in the community and offer what is necessary to fill gaps in available university offerings or to prepare students to take advantage of these courses.

There is one exception to this. One government laboratory annually offers on its premises a comprehensive selection of courses (also available in nearby schools) which meet the academic requirements of a nearby university. The students may take these courses, and, if they desire credit, apply for it in the nearby school. These credits are applicable for any degree for which the course is relevant. There were 63 courses offered in the laboratory in 1967.

Among the other six laboratories offering in-lab, non-credit courses, three also have university-taught courses on the premises. There is little or no overlap in content between the one and the other type of course. However, as noted earlier there is some use of in-lab, non-credit courses to prepare students to take university-taught credit courses. The potential for this kind of updating preparation is much greater than is being realized. Among these six laboratories, one offered 80 in-lab, non-credit courses in 1966-67; the others offered from four to 20.

Managements which do not offer in-lab, non-credit courses cite the following reasons:

1. Six of the ten laboratories say there is a wealth of university credit and non-credit courses and other opportunities available in the community at convenient times and places. The interviews with the university people in these communities confirm this judgment.

2. Two say that they are not aware of any demand from their scientists and engineers for in-lab courses. Both these laboratories have a high proportion of Ph. D. s, and do not operate under the pressure of deadlines or particular commitments to finish a project within a given length of time. Both can be characterized as having a "university-type" atmosphere of which they are very proud.

3. One laboratory cites lack of funds; another is currently investigating the need for, and value of, this mode for their research people.

While we can accept the fact that certain large urban centers have a wealth of opportunities for continuing education, it is also worth emphasizing that managements who rely exclusively on what the community offers are inevitably, by omission, failing to assist:

a) those marginal people who do not make the effort to seek opportunities outside the laboratory,

b) those who cannot take advantage of opportunities in the community for reasons of job pressures or family responsibilities,

c) those who are afraid to return to the competitive atmosphere of the university classroom.

In-Lab, Non-Credit Courses vs. University Credit Courses. In-lab, non-credit courses are quite different from university credit courses. In-lab, non-credit courses are characterized as follows:

1. held on the laboratory's premises;

2. usually taught by laboratory-employed experts who are familiar with the work of the laboratory;

3. need not conform to an arbitrary time period such as a quarter or semester;

4. are flexible in content and requirements depending on the needs of the student group.

By comparison, university credit courses can be characterized as follows:

1. primarily oriented to students in degree-seeking programs;
2. taught by regular faculty or those who have been qualified by the regular faculty as adjunct professors;
3. must meet academic standards for both student and teacher performance as set by the regular faculty;
4. must cover a set amount of content regardless of the interests of the student or its relevance to his work.

In comparing in-lab, non-credit courses with university credit courses, there is general agreement among those who have taught such courses, those who have taken them, and managers and staff that in-lab courses cover less content than university credit courses. Three reasons are given for this:

1. The in-lab, non-credit courses proceed more at the pace of the student.
2. Most in-lab courses fill in background material that full-time university students have obtained from prerequisites.
3. Student performance is measured by less demanding and different standards than those typically set by universities.

This combination of reasons is why people believe university courses result in more thorough training at a higher level of learning than in-lab, non-credit courses. On the other hand, such high-level training is neither necessary nor desirable for the continuing education objectives of many people.

> In-lab courses I took were to maintain a certain level of mathematical competence and to obtain some knowledge of subjects that could be useful in my field. These courses are very convenient being offered right at the lab. It would be nice if university credit could be obtained from these courses. One bad point about these courses is that the instructor does not push the student. Sometimes tests are not given. If tests were given and the student had to work a little harder, it is my opinion that one would get much more out of these courses.
>
> Bachelor's, Mechanical Engineering, age 34

A typical comment from a laboratory scientist who has taught an in-lab course is:

> My opinion is that courses taught here in the laboratory fall short of the rigor found on the outside. You assign homework and no one does it. That

> runs through all these things. The students won't get out for a company course the way they do for one they pay for and go to. (Do they learn what they need to know?) They'll learn it if the teacher can get through their apathy or whatever it is. Their attitude seems to be "if I don't have to work for it and you can pour it in, okay." I had a 50 percent mortality in my course because of this attitude.
>
> Ph.D., Nuclear Chemistry, age 40

Perceived Advantages of In-Lab, Non-Credit Courses. There is consensus, nevertheless, that in-lab, non-credit courses have some special advantages for continuing education.

Three of the seven laboratories offering in-lab courses (two industrial and one government) were studied intensively through interviews and questionnaires. Approximately 35 percent of the scientists and engineers participating in this study have attended in-lab, non-credit courses in the two years prior to this study. In both industry and government, scientists and engineers have attended in roughly this same proportion. The following are the most frequently referred to and discussed advantages of in-lab courses.

1. The most important advantage, from the point of view of both managers and students in these courses, is that the orientation of the course is directly applicable to the laboratory's work. The courses are, or can be, specifically oriented to current or developing research in the laboratory and thus directly oriented to the needs of the student-employees. This means that employees can use these courses for any one, or a combination, of three objectives: to learn something needed on the job; to acquire knowledge in an allied or adjacent field; for refresher and updating purposes.

2. Because all the students are employed in the same laboratory, discussions of problems in class are more meaningful, since the students share a common background in the laboratory work. Discussions are also more free, as there is little or no concern about proprietary information becoming available to competitors.

3. In-lab courses are convenient to take and do not present the barriers which hinder people from taking advantage of university courses and other off-site activities. In-lab courses are typically held either during working hours or immediately afterwards. There are no driving or parking problems, and the student can get home in time for dinner with his family.

4. In-lab courses provide valuable opportunities for older researchers to refresh and update their knowledge. As noted previously, older men often say they feel uncomfortable in the university or other off-site classrooms in which they must compete for attention and grades with younger students who may be much more up to date in a

> particular subject. They are more comfortable learning in a situation with their work colleagues and peers who recognize, and give deference to, their position and experience.

Expressed Needs in In-Lab Courses. As pointed out in Chapter IV (Table IV-4), 17 percent of the questionnaire sample cited some need pertaining to in-lab courses. In addition, in-lab course work needs were discussed with the interview sample. The following discussion is based on both sets of data.

The principal demand stated in both sets of data is for a greater number and variety of in-lab courses. The expressed need is mainly for advanced courses which are designed to fill gaps in the new, developing fields in which the laboratory professionals are working. This is presently the kind of course which is most lacking in those laboratories which offer in-lab, non-credit courses. The second most frequently expressed demand is for refresher and updating courses. And the third demand is that these courses have credit in a university. This is often brought in as a side issue, an "extra" that would be nice to have.

Many people with bachelor's and master's degrees would like to have university credit for whatever courses are available on site. Current arrangements for university credit courses in-lab are atypical so far as could be determined from visiting schools (see Chapter IX). A corollary question is whether people would take university credit courses on site to the same extent they do non-credit courses. This study does not deal with this question, but undoubtedly some people are taking in-lab, non-credit courses who would drop out of needed course work entirely if standards were raised and the risk of failure heightened.

Chapter IV noted that in-lab formal courses were relatively low-ranked in importance for keeping people up to date compared to some of the other modes. The study data do not fully explain the anomaly between this relatively low ranking of importance and the perceived advantages of in-lab courses presented in the preceding section. Much of this apparent paradox is probably a result of the quality of the courses, that they are, indeed, suitable for people with bachelor's degrees but too low-level for those with advanced training or considerable experience. Combined with this is the demand for higher-level courses, particularly in advanced fields in which the laboratory works. Courses at this higher level are now those most lacking in the laboratories which offer in-lab courses at all. Therefore, it is reasonable to conclude that in-lab, non-credit courses as a mode of continuing education have advantages and potential which are not being realized. The expressed needs suggest that laboratory managements should periodically and systematically evaluate the need for in-lab, non-credit courses to insure that whatever course work needs exist among the R&D scientists and engineers are being met, either through facilities in the community or through the laboratory itself. Some recommendations designed to exploit this potential are given in the next section.

Conclusion. In-lab courses are an excellent vehicle for reaching the refresher and updating objectives of continuing education. A few well-designed programs of courses lasting over relatively long periods of time are well known and well publicized in the literature. Among these are the programs designed to update engineering managers (Chapter I cited Sandia's course, which is patterned after General Electric's). Similar integrated programs of courses could be designed for updating scientists, engineers, and managers in research. But in these 17 laboratories, there is no coherent and systematic continuing education program for R&D non-supervisory researchers similar to those well-known programs for engineering managers at Sandia and elsewhere. Indeed, there is little or no over-all planning for coordination among the various employer-sponsored modes in most R&D laboratories. Thus, the reality of a continuing education "program" for researchers, consisting of integrated parts meshed together to achieve some desired objective of "up-to-dateness," is a mirage.

With specific reference to in-lab, non-credit courses, in most laboratories, there seems to be a miscellaneous aggregate of in-lab, non-credit courses, each offered when there is a sufficient number of people who want it. In this way, the student-employee acquires some knowledge. But this is a small part of the spectrum of knowledge required for him to keep up to date or be brought up to date if he has fallen behind. There is little or no planning to have these courses integrated to meet an updating, refresher, or diversification objective covering a broad area of knowledge needed in the laboratory's work. For example, in one laboratory where approximately 20 in-lab, non-credit courses are offered annually, one supervisor said:

> It's a catch as catch can proposition. There is no order in these courses. When enough clamor for a course, then it is given. If you miss it, you never know when it will be offered again. There is a need to plan them farther in advance, find out what a person would find helpful. Now a decision is made on the basis of filling up a class.
> Ph.D., Microbiology, age 43, Supervisor

On the other hand, there is also little or no management thinking given to the place of in-lab, non-credit courses in the whole spectrum of needed continuing education activities. The kinds of needs in-lab, non-credit courses are uniquely designed to fill best have been pointed out. But there is a risk in leaning too heavily on this mode of continuing education to the exclusion of others. The student body in such courses is homogeneous, and the laboratory-employed teacher is part of this homogeneity. The risk involved is one of narrowing the training, and therefore the interests and capabilities of research employees who are not also exposed to cross-fertilization from outside the laboratory. This cross-fertilization may come about through many sources, but outside contacts with other people are among the most stimulating and provocative sources of new ideas and insights. In-lab, non-credit courses should not be used as a substitute for other modes of continuing education which provide and create these contacts.

We recommend that laboratory managements should annually review whether or not course work needs are being met by facilities in the community. If not, then laboratory managements should sponsor in-lab, non-credit courses in those subject matter areas which are needed. At the present time, there do not appear to be such annual evaluations in any of the laboratories.

We further recommend that refresher and updating course work be offered in all laboratories, because university and other course work modes of continuing education do not seem to us to meet this specific objective. In-lab, non-credit courses seem the best answer to the need for refresher and updating course work, providing the standards of student performance are adequate to insure learning. None of the other modes seem to be as well suited to these objectives. If needed, these refresher and updating courses should be planned and integrated into a program or series of courses so that the refreshing and updating which takes place (in a field or discipline) is comprehensive rather than spotty.

It is entirely possible and even desirable that these programs can be worked out with nearby universities or through professional societies. The American Chemical Society now makes available nine of its short courses to organizations which wish to sponsor them, and plans to offer more. The Society provides the teaching staff and the materials for each student. All other arrangements are up to the sponsor.[2] The Seattle Professional Engineering Employees Association has worked out (with the University of Washington and several employers) a course work plan for its membership designed "to update engineers over a broad range of engineering applications and science subjects."[3] After completing the plan, the engineer must seek additional depth in subjects of personal interest.

In addition, laboratory managements should evaluate the need for advanced course work which is not available otherwise in the community in the fields and disciplines in which the R&D scientists and engineers are working. Because course work is said to be the best way of learning the fundamentals of a subject in depth, laboratories should seek to provide this mode of continuing education as a supplement whenever nearby universities and other facilities lack appropriate courses.

Outside, Short Intensive Courses

Outside, short intensive courses are *non-credit and require full-time study* of a single subject for a period of time lasting from two or three days to about six weeks, but most typically for one or two weeks. The registrants are away from work and usually also away from home. Outside, short intensive courses have the following characteristics:

1. The individual registrant is free from the demands of his work and, if away from home, from family and civic responsibilities also.

2. The course consists of lectures interspersed with discussions (and sometimes demonstrations but rarely laboratory practice)

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[2] "Education Office Launches ACS Package Courses." *Chemical and Engineering News*, June 17, 1968, p. 57.

[3] *SPEEA Plan: Continuing Engineering Education* (previously cited in Chapter I).

and supplemented by reading materials from which assignments are commonly given.

3. Fairly rigid schedules are maintained, and typically there is somewhat more subject matter planned than can be comfortably fitted into the time allowed. That is, these courses are fast-paced.

4. There are usually no examinations, grades, or other measures of student performance.

5. Certificates of completion are given to registrants who complete the course.

6. These courses are relatively expensive per man for the employer, because of the fee and the loss of productive work time.

Universities and professional societies are the main sponsors of outside, short intensive courses. With few exceptions, the people in this study who have attended any short course have attended one offered by a university, the American Chemical Society, or the Gordon Conferences. The following points summarize their experience:

1. The American Chemical Society is the only scientific society we learned about that offers short intensive courses. These are well known to the chemists and chemical engineers interviewed, as they are to the R&D management personnel interviewed.

2. The engineering societies are reported by our sample to offer short courses at local chapter levels and at the national level. However, we do not have any specific information on these. (This study did not include a responsibility for developing a survey of course offerings.)

3. The Gordon Conferences are well known to many of the people participating in this study -- to some through participation in one or another of these conferences and to others by reputation.

4. Manufacturers of equipment are also reported to offer short intensive courses on the use of the equipment and the science and technology behind it.[4]

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[4] We are aware of the fact that some manufacturers of equipment and other vendors to laboratories make presentations to scientific and engineering personnel. Very few of our interview sample mention this type of presentation in discussing their continuing education activities. The four or five who do mention it say that the presentations explain the scientific and engineering technical background of the equipment or product so that they could better see potential uses of it in their work. We regard this as a significant kind of effort but are unable to report on it because of the scarcity of its use among the personnel studied. It may be that presentations of this type are relatively unfamiliar to the kind of research personnel included in this study.

As noted above outside, short intensive courses last for varying periods of time. In four of the universities visited for this study, there is a special kind of short course which meets periodically rather than concentrating all the course work in one block of time. These non-credit short courses may meet once a week for eight to ten weeks and consist primarily of lectures by different experts each week, or they may meet all day or a day and a half every other week for two concentrated periods, or they may be non-credit courses of the regular kind, meeting weekly for a quarter or semester. One of the universities has actively promoted this latter format in a broad spectrum of course work. Northeastern University in Boston offered 55 "state of the art courses for scientists and engineers" in its Spring, 1967, catalog. These courses meet one evening a week for 12 weeks.

All of these variations of non-credit concentrated courses lead us to believe that the trend will be to develop a variety of different time periods. Hopefully, additional courses will be developed specifically for refresher and updating purposes as well as for new advances in the state of the arts. The scientists and engineers interviewed for this study have participated mostly in short courses of one or two weeks time; this is the frame of reference they used in discussing the pros and cons of short courses.

Laboratory Policy and Practice. Fourteen of the 17 laboratories claim to use outside, short intensive courses as a mode of continuing education. This indicates that this mode is well known and widely accepted as a method. However, actual practice in these laboratories gives a somewhat different picture.

In seven of these 14 laboratories (two government and five industrial), top management reports "few" people are actually sent to such courses. From the figures available in some of these laboratories, "few" means under 20, a very small percent of the professional research work force. These laboratories may be considered to be making minimal use of this mode of continuing education.

In the other seven laboratories (two industrial and five government), short intensive courses appear to be more extensively used and, in addition, to be planned for as a mode of continuing education. However, reliable figures on the number actually attending are not available in either of the two industrial laboratories, because the decision to send an individual is made by a department manager in consultation with his supervisor. The expenses are paid out of the department travel budget and not differentiated from other travel expenses. This means that there is no record of use of this mode, since no independent record is kept. In the government laboratories, the figures are not comparable from laboratory to laboratory. In some, the records are not based on figures limited to research professionals; in others, management training is included in the records kept.

Twenty-two percent of those completing the questionnaire report having attended a non-credit course in the past two years.[5] It is not uncommon for a man to attend more than one short course in a given year, although it is rare that this would continue year by year. As noted earlier, engineers more frequently used this mode than do scientists.

Advantages and Disadvantages. Among those who have taken short intensive courses, there is consensus on the following four major advantages of this mode of continuing education:

1. Short intensive courses are described as "self-contained" in that they deal with a specified and limited amount of material in a short period of time, and do so in a way that makes the content applicable to the registrants' on-the-job needs. This applicability to the registrants' job is the task of the short-course instructor. When the course starts, he must assess the state of readiness of the group of registrants and their ability to absorb what he intends to teach. By determining their interests and some of the problems they are interested in, he can adjust the content of the course to make it relevant to these problems. According to people who have taken them, this is one of the advantages of short courses, because they increase the "fit" of the course to the participants' on-the-job problems. A "successful" short course also prepares the student for subsequent self-directed study of the subject once he is back on the job. Many courses provide detailed notes for just such application.

2. While taking a short intensive course away from work and home, the individual is free from the pressures and responsibilities of these ties and free to concentrate all his energy and attention on the

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[5] The PEI report indicates that 15 percent of the R&D engineers took a one- to three-week university-sponsored course in the period of 1960-65 compared with an over-all figure of 9 percent for the total group surveyed. The figures given in the PEI report can be converted to percents to compare the different functional groups they surveyed. See: Continuing Education of Professional Engineers (previously cited in Chapter I), p. 18.

course content. Learning is thus enhanced. In addition, the individual has time to engage in serious discussion with other registrants from other organizations, not only in class but also during mealtimes and after hours. This feature of short intensive courses is often as rewarding as any other in terms of information obtained. It also enhances the possibilities of cross-fertilization of ideas and concepts. One man evaluated his experience as follows:

> I have taken two short courses. Each one was for one week. The one was fairly intensive lectures all day and lab in the evening. (How would you evaluate that week?) For me, one of these two courses carried me forward about three years. I really think it's an exceptional course, and I was ripe for it. It was a great deal of help to me in my development. The other one was more specific. I could have learned what I learned at the course picking at it on my own over six months. We aren't given a great deal of time to do this rummaging about although I've had to do it. I think what was good about the first one was the total immersion in it all day and evening. There were no distracting influences. (Could you elaborate on the total immersion aspect?) If you compare it with a longer course, you rush down there all out of breath, with all your daily problems on your mind, and you do the homework at the last moment. Like so many things, it's diluted by everything else you have to do.
>
> Master's, Civil Engineering, age 36

3. Because they are so compressed in time, short intensive courses are especially suited for those who travel a great percent of the time, those who work long hours, and those with an immediate need to know. In the aerospace industry in particular among the laboratories in this study, heavy travel schedules and long hours are a feature of many assignments. People who are committed in these ways are not able to utilize the other course work modes of continuing education. They are ordinarily unable to attend enough class sessions of university or in-lab courses extending over a quarter or a semester to make registering worthwhile. Particularly when the courses involved are for credit, people with such extensive job commitments are concerned that they will not be able to devote the time to a regular course or to attend with enough regularity to enable them to do well. For these people, short courses are an available mode because they can be fitted into travel schedules and work deadlines more easily than other course work.

Occasionally, an unanticipated need may arise to know a particular subject or acquire a specific skill. This seems to occur most frequently when people change job assignments. Taking a credit course or teaching oneself may be neither thorough enough nor quick enough to allow one to become sufficiently prepared. Short intensive courses, if available when needed, are considered especially well suited to this situation.

4. The instructor's professional and practical identification with research scientists and engineers enhances his stature in their

> eyes. They regard the instructor as an "expert" and the learning experience as coming straight from another practitioner and thus more directly relevant to on-the-job problems than university course work. In this context, an "expert" is not merely an instructor who knows the content. His expertise is felt to consist as well in his ability to teach mature research people and to make the content meaningful in terms of applications to the job. Instructors who do not have these abilities are criticized as "blue sky" or "too theoretical." Sponsors also emphasize these qualities in their search for instructors, as illustrated in the promotional material they prepare. The men interviewed express a preference for an instructor who has been heavily engaged in solving research problems similar to those they have on the job. These instructors are said to have a "feel" for the research problem which the strict theoretician lacks.

> A few years ago I took a two-week course at the University of Michigan. It was good in the sense that it was taught by people who were experts. The first week was sort of introductory, but the second week was experimental. Also, two of the people were active in the field, and after hours we had lots of discussions. On these summer courses you do have experts and you can ask them questions. I also took another one-week course there just after I changed jobs. With a one-week course I learned a lot, and knew then which way to direct my studies. It made me more knowledgeable about things going on.
> Master's, Physics, age 31

Short intensive courses are said to have the following two major drawbacks, the second of which is an important problem but not a disadvantage of the short intensive course per se.

> 1. The rate of absorption of material is less in a short intensive course than in a credit university course or other longer course spread out over time in which the student does more work on his own (providing, of course, that he does the work). The reasons cited for this are that in longer courses, with intervals between class hours, the student spends more time in reflection and study, in homework, and in solving problems. The converse holds for short courses which are described as "crammed." For example:

> I have attended some of the summer short courses that are so plentifully offered these days. They're not as useful as a regular semester type graduate course. They're too much of a cram session. But, nevertheless, they do have some usefulness. One learns from them, but I don't think you learn as much per hour of class as you do when it's spread out over a long period. I have been to four of these, I think.
> Master's, Physics, age 53

> While the cramming produces a certain pressure to keep up with the material as it is presented, it does not serve the same function as the pressure of grades and examinations does for learning. In the short

intensive course, it is the reverse of pressure that is lacking, that is, the time to reflect, assimilate, and absorb the content made possible in the intervals between classes (assuming the student takes the time to study between classes).

I have doubts about short intensive courses. They compress things and don't give you time to do the homework you would do in a full course. And they cater to too broad a spectrum. The main criterion is the availability of the two or three hundred dollars which they charge. There is no grading. For me that's a disadvantage. I find that having to work for grades still creates a helpful pressure. It lowers the sights of the people taking the course and of the instructor giving it when there are no grades. But these courses are fantastically popular just for this objective of preventing obsolescence. A two-week course usually runs more hours than a full course, yet the amount of benefit you get from the latter is much greater.

Master's, Electrical Engineering, age 33

On the other hand, a "successful" short course prepares the student to study the materials again when he is back on the job. If a short course succeeds in this, then perhaps this drawback is not quite as critical as some of these men say it is.

2. The second major drawback is the difficulty of obtaining sufficient information about short intensive courses in order to be able to select that one which best fits the individual's needs. The difficulties stem from inadequacy of information as well as the haphazard process by which it becomes available to scientists and engineers.

Research people report obtaining information on short intensive courses from:

a) Brochures and announcements received directly from universities and other sponsors who have their names on mailing lists,

b) Materials from colleagues or their supervisors,

c) Personnel and training staff who are responsible for continuing education. These staff people may maintain a file of current announcements as well as keep in touch with various sponsors of short courses by letter, telephone, and personal visits. This is the case in the laboratories which make extensive use of short intensive courses. In one laboratory, personnel who attend short intensive courses are required to fill out a brief evaluative form which is used in advising others inquiring about the course.

We obtained approximately 125 brochures and short course announcements from the universities contacted for this study. An examination of these brochures reveals that:

a) The course is described only in general terms, usually in only one or two paragraphs.

b) A topical outline extends the description and is used to describe the scope of the course and the allocation of time.

c) The instructor is introduced via his qualifications for teaching the course. Emphasis is placed on his practical experience.

d) There is usually no statement of desirable or required prerequisites. Even where the text to be used is announced, there is no indication of advance preparation to be required.

e) There is no statement of the continuing education objectives to be served, that is, whether for refresher and updating, extending knowledge into a new field, covering recent developments in the state of the art, etc.

f) On the other hand, there is usually a statement of the kind of person (in what kind of work) who is most likely to benefit from the course.

When these points came to the fore during the course of the study, they were discussed with several directors of centers of continuing education in universities. The reason given for vagueness in stating prerequisites is the desire to include as many people as possible who can benefit. Admittedly it is difficult to state prerequisites for a broad spectrum of research personnel likely to attend a given course, because their backgrounds vary so much with their experience. However, the lack of any statement strikes us as a glaring omission.

Conclusion. There appears to be no obvious reason why short courses cannot require prerequisites of the kind that would enhance the rate of aborption of the material. A review of fundamentals, or a quick reading of the proposed text or some other material, might easily be required prior to attending the course. This would reduce the pressure from the "cram" feature of short courses. Undoubtedly, however, it would also reduce the number of students who would register. How any prerequisites would be enforced is a problem similar to that of enforcing prerequisites presently required for university credit courses. We recommend that student performance in short intensive courses be scrutinized further in other research.

We also recommend to management that they collect materials pertaining to short intensive courses (including participant evaluations) in a central place so that this information is readily available to supervisors and research personnel for their guidance. This will make it easier and more efficient to select the appropriate short course by providing the individual with as much information as is available.

A central clearinghouse type of listing is a natural function of a professional society. There are excellent examples to be found in Chemical and Engineering News, published by the American Chemical Society, and in the American Dental Association's quarterly, Continuing Education, both of which are distributed to all members on a regular basis. Professional societies which do not now provide this service to their members should establish such a clearinghouse through their regular publications.

Summary and Conclusions

All three of the modes presented in this chapter have a distinct contribution to make to continuing education. University credit courses are most suited for in-depth learning of the fundamentals of a subject. R&D personnel who want to have a thorough grounding in a subject take university credit courses for this purpose. Among members of this sample, such courses are primarily used for diversification, that is, for learning the fundamentals of a subject not previously studied. They are only rarely used as refreshers; seldom does a researcher take, once again, a course he has previously taken.

In-lab, non-credit courses sponsored and taught by employers may also be used for learning the fundamentals of a subject -- they may serve this purpose, but our R&D scientists and engineers say they do not learn as much in such courses as they do in university credit courses. Whether or not "as much" is desirable or not depends almost entirely upon what is needed by the individual student. We suggest that the high level of student performance in university credit courses may not be necessary for the purposes of many individuals. Many individuals may very well learn all that they need to know to enhance job competence in less demanding courses. However, it would be desirable to know more about the quality of student performance in in-lab, non-credit employer-sponsored courses. Consequently, we recommend that management undertake the same type of evaluation which is exemplified in the literature evaluating management and other types of personnel training. To our knowledge, such personnel research techniques have not been applied anywhere in the field of continuing education for scientists and engineers.

On the other hand, among the course work modes, in-lab, non-credit courses are uniquely fitted to serve the refresher and updating needs of R&D personnel. While mathematics is one area singled out for special attention, in-lab, non-credit courses can be used to refresh and update personnel in any subject matter area useful to, and needed by, the laboratory personnel. A special use of such courses is to prepare scientists and engineers to take university credit courses for which they do not have the prerequisities. No other mode of continuing education seems as well suited for these objectives as in-lab, non-credit courses. This reinforces the need to know more about student performance in such courses.

If the community resources lack substantial opportunities for updating, we recommend that laboratories sponsor in-lab, non-credit courses specifically for updating and refresher purposes, with an emphasis on the mathematical groundwork of the disciplines and fields in which their people are working. An alternate way of achieving this goal is support of local chapters of professional societies in offering such courses or obtaining university assistance.

We also recommend that participation in these courses be dependent on the student-employee's willingness to meet the standards of required performance set and enforced by the instructor in these courses. These instructors should be encouraged to set standards and to require whatever level of work they think is reasonable in light of the laboratory's needs in the subject-matter area. At the present time, these courses are criticized by many people, both by those who are motivated to learn and those who teach them, as not being demanding enough.

Outside, short intensive non-credit courses are especially valuable to those whose job demands and other commitments do not permit attendance at courses stretched out over a longer period of time. They are also valuable to those desiring quick, but not necessarily deep, understanding of a subject-matter area. Partly because of their "away-from-the-job" feature and partly because of their convenience, short intensive courses have considerable potential for continuing education. The main drawback of such courses is that people find it difficult to maintain a high rate of absorption of the material studied over a one- or two-week period. Perhaps the effects of this drawback can be lessened by requiring some prerequisite, such as a reading of the text to be used or other preparation appropriate to the course content. This is an uncommon, although not necessarily rare, requirement of the course brochures examined.

It may very well be that the prestige of both in-lab, non-credit courses and outside, short intensive courses will be enhanced if the students "qualify" for them by having to reach some stated level of achievement. On the other hand, it is also likely that raising standards of student performance will cause some marginally motivated people to avoid these modes. However, this appears to be a different problem apart from any specific mode. Individual problems of motivation should be solved by dealing directly with the individual in terms of his job, his future prospects, and rewards.

CHAPTER VI

INTERACTION MODES OF CONTINUING EDUCATION

This chapter presents the data pertaining to three employer-sponsored modes of continuing education which have in common some form and degree of interaction among colleagues. Attending professional meetings and in-lab lectures facilitate interchange of information through discussion or the presentation of some kind of paper or other report of research trends, developments, and findings. Sabbatical leaves also facilitate the exchange of information on a long-range basis between the individual on leave and colleagues he comes into contact with during the course of his leave.

Each of these three modes of continuing education is discussed separately in this chapter. Some generalized functions of interaction with colleagues are also presented as reported in the interviews with the 205 scientists and engineers. These general findings are drawn from the statements which people make about the value of being in touch with others working on the same or similar problems in research; they are not repeated for each of the modes separately. The reader must remember that these general features of interaction are a part of each of the three modes in this chapter. They are, as well, aspects of the larger role of information dissemination within which continuing education takes place.

This larger role of information dissemination needs some elaboration. Continuing education has specific objectives which have already been defined: refresher, updating, diversification, and keeping up to date. Keeping up to date is primarily a process of keeping in touch with new developments as they occur. Keeping in touch in this context means knowing the latest information coming out of research, both in publications and through personal contacts with colleagues in the same field. What is important for continuing education purposes in respect to technological obsolescence is keeping up to date with those developments relevant to one's own work. To remain competent on the job, it is not necessary for a researcher to keep up to date with everything of interest, only with that which is related to his work and the fields of specialization in which he must maintain competence to work. Thus, continuing education objectives are more narrowly defined than keeping up to date generally with scientific or technical developments in the same field -- what is critical is what pertains to the job in hand or the relatively short-term future. Beyond this, what is of interest to particular individuals in research may be worthwhile, and even eventually useful to them, but it is not necessarily continuing education defined as enhancing job competence.

There is a need for further and more explicit theoretical formulation of the boundaries of continuing education and of the gray area between the objectives and functions of continuing education and the objectives and functions of intellectual curiosity which leads people beyond the confines of enhancing job competence. For example, the extent to which interaction with colleagues serves as a stimulus to specific continuing education activities (e.g., reading further, taking a course, etc.) and to what extent it is itself continuing education, that is, the acquisition of specific pieces of information useful on the job is not known. With reference to the latter, the following observations are offered as a stimulus to further thought in this area.

The Functions of Interaction with Colleagues

Interaction with colleagues is an important feature of the researcher's work life, because it creates that network of interpersonal relations through which significant new research findings are spread throughout the scientific and engineering community in advance of publication. Having such information as early as possible is always of value to an individual's research. In addition, interaction with colleagues provides that kind of stimulation which is so necessary to maintain interest in, and enthusiasm for, research as an intellectual process.

Approximately 30 percent of the 205 men interviewed discuss interaction with colleagues as one of the important sources of information and stimulation in keeping themselves up to date with the state of the art. Interaction with colleagues for this purpose is a feature of several modes of continuing education (attending professional meetings, in-lab lectures, outside short intensive courses) as well as discussions with consultants and with co-workers within the laboratory.

On the basis of these interview data, five specific objectives of interaction can be distinguished. (These are identified in the first column of Table VI-1. The second column lists the information received from a colleague. The third indicates its value to the receiver.) The first two of these -- obtaining suggestions for further study and getting help in understanding -- are two of the characteristic ways in which people working in the same laboratory help each other. For example:

> My work is in radiation and sterilization. Some people may consult me about some aspect of radiation techniques that I know about even though I don't know anything about the problem they are working on. When my techniques are rusty or something, I consult other people for help. They are very free with their time, very cooperative; they go out of their way to tell you what you want to know.
>
> Bachelor's, Zoology, age 39

The next two objectives in Table VI-1 -- obtaining help on applications and decisions -- are achieved with about equal frequency (according to our interviews) with colleagues within the laboratory and those outside it. The last objective, keeping current, is emphasized as the particular value of being in touch with people in the same field who are located outside the laboratory.

In all these specific uses of interaction, part of the emphasis is on the time saved for the researcher. Use of experts in a particular subject saves the research person the time and effort of searching the literature himself, taking a course, or reading a textbook. For example:

> I don't need to be an expert in titanium even though it's the metal I work with. I have an expert on titanium right down the hall, so I don't need to be up on it. Yes, I'd like to know more about it. But I don't have time.
>
> Ph.D., Metallurgical Engineering, age 44

Talking to experts also puts the research person ahead of the literature, because experts are up to date with the state of the art and thus are presumed to

TABLE VI-1

THE OBJECTIVES OF INTERACTION WITH COLLEAGUES

Objective	Information Given by Colleague Consulted	Function Served for Receiver Colleague
Further Study	Points out best or most pertinent sources of information	Saves having to examine other available sources for himself
Understanding	Gives instruction in pertinent knowledge needed to approach a problem or understand research results	Saves becoming expert in the field in which instruction is received
Applications	Gives information on which approaches have been tried by others and with what results	Saves having to test out possibly unfruitful approaches to his problem
Decisions	Gives opinion on one best approach to use; several colleagues can give confirmation of best approach through consensus	Saves having to test out other possible approaches through literature or direct experimentation
Keeping Current	Gives information on current status of own research and of that of others known to him	Saves waiting for publication; is immediately related to own work for guidance and for future reference as needed

have knowledge of new developments in advance of publication.[1]

In addition to the five specific functions, an important general value of interaction with colleagues lies in the stimulation that scientists and engineers say they derive from these encounters and from the feeling of security they associate with being able to contact a variety of experts to find out what is new and exciting in their work. As one supervisor put it:

> In large measure, investigators know who is doing what... From a contact standpoint, meetings are very important -- being able to talk to a scientist directly. I might also add that a meeting is necessary for stimulation. If one works in total darkness, without anyone appreciating his work, he loses stimulation and enthusiasm. There is a psychological stimulation from a meeting that makes it useful.
>
> Bachelor's, Electrical Engineering, age 52, Supervisor

Another supervisor pointed to the benefits of knowing people in the general field in which he works:

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[1] These findings are consistent with the results of other research. Rosenbloom and Wolek, in a study of information transfer in industrial R&D organizations, examined 2,000 cases of acquiring information useful to work from a source outside the immediate circle of colleagues. They report that interpersonal communication represented 55 percent of all the cases described and "even where it was least likely to be used, interpersonal exchange accounted for 40 percent of the cases." They conclude:

"The literature, however, need not be the main link between the needs of the individual professional and the resources of the wider technical world. As we have seen, useful information from distant sources is available through other pathways involving interpersonal exchanges, either exclusively or in concert with documentary sources. The informal network provides guidance to documentary sources of needed substantive information. Interpersonal communication with professionals in other organizations is a common means of access to knowledge which may not exist in the local environment. Information obtained from documentary sources by one member of an organization...finds its application through another member of the same organization who may inquire or have it pointed out to him."

See: Richard S. Rosenbloom and Francis W. Wolek, *Technology, Information, Organization: Information Transfer in Industrial R&D.* Boston: Graduate School of Business Administration, Harvard University, June, 1967, p. 124. (Mimeographed.)

> Attending this conference benefited me in meeting a lot of people knowledgeable in my areas. Just meeting these people, these contacts are valuable. (How are they valuable?) Well, in knowing these people, it makes the subject come alive. Knowing a certain person at Cornell, for example, who works in a similar field, enabled me to call him up and get some information on a new method. I could call him directly and get information from him. Also, another man I met at this conference, I have been corresponding with him on problems.
>
> Bachelor's, Chemical Engineering, age 46, Supervisor

These interpersonal exchanges serve to make research a more stimulating and psychologically rewarding way of life. Keeping up to date with what colleagues are doing is a source of enjoyment per se, but it is also seen by research people as essential to maintaining an active work life in research. Thus it performs a vital continuing education function. There is consensus among the people studied that, without some kind of interpersonal stimulation, the research person tends to dry up and die on the vine. As one biologist said: "How long can you keep coming up with new ideas in the same environment without some kind of stimulation from the outside?"

Attending Professional Meetings

Attending professional meetings is an important means of keeping up to date with the state of the art. One of the primary purposes of professional meetings is to inform those attending about recent and current developments.

Two Types of Professional Meeting Discussed. The research scientists and engineers who were interviewed for this study talk about two types of meeting which help them keep up to date: meetings of professional societies and invited conferences. They did not discuss at any length other types of meeting. The findings reported here refer to the two types they did discuss.

Meetings of professional societies (as described by those interviewed) are characterized by:

1. an audience with diverse backgrounds, interests, and capabilities,
2. papers dealing with the broad range of topics which are classifiable under the society's interests, and
3. considerable interaction on an informal face-to-face basis between colleagues interested in the same topics.

Invited conferences bring together the "experts" in the subject of the conference for the purpose of talking over their latest research results and problems currently being investigated. These invited conferences are characterized by:

1. sponsorship by a special interest organization, such as a laboratory, a government or government agency, a university, a professional society, or some combination of sponsors;
2. a limited audience, whose members are themselves specialized in the topic of the conference; an invitation is a badge of being recognized as an expert in the field;
3. a limited scope restricted to one specialized topic or field of research; and
4. papers which are presented for discussion as much as for information; considerable time is allotted for exploration of ideas through discussion.

Laboratory Policies and Practices on Attendance. Sixteen of the 17 participating laboratories support at least some R&D personnel in attending professional society meetings. The remaining laboratory, citing lack of funds, permits people to go on their own time and at their own expense. There are no written policies on this mode in any of the laboratories, and there are restrictions placed on this activity in all of them:

1. Attendance is at the discretion of the supervisor, who relies on the professional person to exercise a sense of responsibility in selecting the meeting that will be most worthwhile for him to attend.
2. Budgets determine the limitation placed on the total number of personnel attending meetings, necessitating selectivity. For morale purposes and other considerations, management practice usually permits all Ph. D. s and senior research personnel to attend one or more meetings per year; others are selected or approved to attend on the basis of other criteria, such as work achievements and specific on-the-job needs.
3. Giving a paper is the third criterion that eight laboratories (four industrial, four government) customarily apply before approving a request for expenses to attend a professional meeting. High-level research and administrative personnel are usually exempt from this requirement.

Obviously, these criteria discriminate against many of the junior-level people. The basic criteria determining selection are cost considerations relative to benefits accruing to the laboratory. A supervisor commented on his laboratory's practice as follows:

> I think perhaps it's a difficult thing to decide between a person who can get something out of a meeting and the person who is just wasting his own time and the company's money. As a result when you have a company this large, in which a very large number are professional people, you cannot, just on some rather arbitrary basis, decide to include or exclude. But because it's difficult to make the decision, the management process for doing it is inept.
>
> Master's, Meteorology, age 44, Supervisor

A top manager in another laboratory said:

> We cannot send as many people to meetings as want to go. There are budget limitations. Ph.D.s can go to one meeting of their choice each year. The junior levels may go to a meeting every three or four years. People feel this is a constant problem. The bachelor's-level feel discriminated against.
>
> Top Manager, Microbiology

Furthermore, in discussing laboratory practice in support of personnel attending professional meetings, it is also clear in the top management interviews that attending meetings is not solely, and perhaps not even primarily, supported because of a desire to provide continuing education opportunities. We have the impression that support is also a kind of "reward" or perquisite of the job which goes with professionalism and employment as a professional. Thus, this kind of support is provided partly because it maintains professional stature of employees and contributes to the prestige and reputation of the employer organization. These are not continuing education objectives.

All of the laboratories will support an individual scientist or engineer who has been asked to attend one of the special "invited" conferences, that is, give him the time to go and pay his transportation expenses. This is done because of the presumed value of having an expert at the conference who will learn the latest developments going on throughout the world. Those scientists and engineers in the interview sample who described invited conferences they had attended placed great value on them. However, the number who are invited is small; less than seven percent of our interview sample say they have attended an invited conference.

Six of the 17 laboratories (three industrial, three government) sponsor one or more invited conferences each year. These are arranged to bring together the recognized experts in a field of special relevance to the laboratory's work. One purpose of the conference stated by these six managements is to give laboratory personnel the opportunity to interact with experts from outside the laboratory.

Participation in Professional Meetings. This section presents the questionnaire data pertaining to attending professional meetings. The figures given below are based on the questionnaire sample of 394, of whom 231 are scientists and 163 are engineers.

More of the scientists (75 percent) than engineers (49 percent) report they received expenses to attend one or more professional meetings in the two years prior to the study. Over 80 percent of the (115) Ph. D. s received expense money to attend one or more professional meetings as compared to 62 percent of the (117) master's and 55 percent of the (147) bachelor's. Also associated with receiving expenses to attend meetings is high salary, publishing papers, competence in three or more areas of specialization, autonomy in setting own goals in research, and membership in several different professional societies. In short, these are the productive, elite research people. These correlations support the impression reported above that laboratory practice is selective and tends to discriminate against supporting junior-level personnel in attending professional meetings. Thus, as a mode of continuing education, this one is available to the higher levels of R&D personnel, and not as available, or not available as frequently, to junior levels of R&D scientists and engineers. This is elaborated further by the following two sets of facts also derived from the questionnaire data:

> 1. Twenty-five percent of both the scientists and engineers report attending between four and ten professional meetings in the past year without regard to whether or not they received expense money for doing so. Twenty-seven percent of the Ph. D. s, 30 percent of the master's, and 20 percent of the bachelor's have attended four or more meetings in the past one year. In other words, those who attend four or more meetings are not distinctively Ph. D. s, not distinctively scientists. However, those who attend four or more meetings per year are older and in higher salary brackets than those who attend three or fewer. This latter distinction is important, because it suggests that achievements on the job and/or seniority play a significant part in determining who goes to meetings since both scientists and engineers and all levels of degrees have about an equal opportunity to attend four or more meetings.

2. Twenty percent of the scientists and 44 percent of the engineers have attended no professional meeting in the year preceding the study. Ten percent of the Ph.D.s, 31 percent of the master's, and 43 percent of the bachelor's say they attended none. Furthermore, 35 percent of those age 35 or younger have attended none compared with 24 percent of those 36 or older.

In all the data reported in this section so far, there is no significant difference between government and industry employment.

Taken together, these data raise two questions. One is, should more of the younger non-Ph.D.s be supported in attending professional meetings? Considering only the continuing education objectives, the answer is "yes," because attendance would enhance the amount, or at least the potential, of continuing education taking place. The second question is, does management select personnel to support at meetings who are most likely to benefit? Again the answer is "yes," because the correlations suggest that it is, indeed, the more productive people who are now attending. However, to what extent the productivity of the junior-level people is being lowered by being deprived of the stimulation, motivation, and actual learning attributed to attending professional meetings is a special issue which this research does not evaluate. We suspect that it is being impaired and limited to at least some extent. For example, one manager said:

> The junior people would benefit from attending meetings, but we have difficulty getting them there because of funds. When I went to my first meeting 18 years ago it had a tremendous impact on me. I came back all fired up and enthusiastic. So it's very important. It serves in a really nice way this motivation to continuing education. It's not just the technical information but the image and impression they get of their own field.
>
> Ph.D., Physical Chemistry, age 46, Top Manager

The next section presents three specific ways in which scientists and engineers say professional meetings contribute to their continuing education.

Appraisal of Meetings by Participants. The R&D personnel interviewed state that the three activities at professional meetings which contribute to continuing education are short papers, long papers, and discussions with colleagues about research.

1. Short papers of ten to 30 minutes in length are of interest and value only to participants who are themselves interested in, and up to date with, the research topic presented in the paper. Typical comments about short papers are:

> I would say maybe ten percent of the papers I've listened to at meetings really imparted some information to me. (What is wrong with the others?) It's the same way with these short courses. How much knowledge can you impart in a half an hour? Basically only a simple concept. But the speaker deals in a complex concept. In a half an hour you can't keep up with the man. Most of us who go get more out of symposia than papers. If you are not working in the area of the paper, the narrow area, you can't even generate a question to ask in a half an hour. The only question you can think of is: will you start over again?
>
> Bachelor's, Physics, age 37

Another identified this characteristic of short papers as follows:

> Often a fellow working on a project condenses too much into 15 minutes. And it's too much to understand. He is presenting his data and conclusions, and no background. Or only two or three minutes of background, and that is not enough. You've got to be well versed in the subject to get the point of the paper. Often I come out of a meeting like that thinking I had wasted my time because of this. Too many slides, too much on them, not enough time to absorb what is on the slides. So I've been disappointed in many of the short papers. (What do you think would be better?) They have what they call symposia at these meetings on special subjects.
>
> Ph.D., Physical Chemistry, age 31

Short papers are confined to reporting results and conclusions without dealing with the implications of findings for the broader area of the discipline. That is, short papers do not integrate any part of the field for the audience. Consequently, for those who are unable to do this for themselves, short papers are not a means of keeping up to date.

2. Long papers last from 30 to 60 minutes or more and are categorized as "review" papers and "symposia." Review and symposia papers provide background information and integration into theory which gives participants a feeling of being up to date with broad general developments. Long and short papers are contrasted by one man as follows:

> I had to give a paper at one meeting. Each speaker had 15 minutes and four for questions. There were eight speakers between 8:00 and 12:00 noon. If it had been one or two less it would be easier to listen to. Not all these papers tell you something you want to hear. The rate of absorption varies as a function of time. You may be interested in one or two out of a day. You concentrate on those... (What are the advantages of longer papers?) You pick the subject you are interested in. Then you may follow the speaker from the beginning. In other fields you're not working in, it's sometimes difficult to follow a paper without an introduction and background. A concise but informative introduction with an explanation of the

laws to be used helps immensely and makes longer papers more interesting in a subject you are not actively involved in.
Master's, Electrical Engineering, age 23

3. Discussions with colleagues relate to continuing education in terms of specific information obtained and stimulation to undertake specific directions in research. These take place not only at professional society meetings but at all other kinds of meetings of research people, both formal and informal. The following are some representative comments:

> Take this one meeting in particular. There were very well-known protein scientists there, and I had an opportunity to speak to them and receive suggestions on some of the problems I have encountered.
> Master's, Biochemistry, age 26

> Sometimes going to a meeting means the difference between a successful project or not. Someone could come out with a new gadget to measure the speed of a bullet. This is very important to us. You talk to people with similar problems and sometimes come up with a good solution.
> Master's, Physics, age 52

> So many of the papers go into so much detail you can readily get lost unless you are familiar with the field. Whenever you are talking to others, you are talking to people in your own area. There are always a few papers that give you a lot of information. As a rule, conversations give you more.
> Bachelor's, Chemical Engineering, age 31

Supervisors and managers also recognize the value of this aspect of professional meetings to the development of an individual's interest and enthusiasm in his own work. They too have had the rewarding experience of getting "all fired up."

> It's very hard to show the value of attending meetings. Yet it's almost impossible to maintain a professional standing if you never attend meetings. At this level of professional work, interaction with your peers is the most stimulating thing that you encounter.
> Master's, Meteorology, age 44, Supervisor

Invited conferences are said to be superior to professional society meetings in that all papers are germane to some central theme, and discussions center around new approaches to problems in the field. Their distinctive function is to define the present state of the art and indicate directions research should take from this point. Those who attend invited conferences say they are the source of much new experimentation and investigation and often of collaborative efforts between scientists in different laboratories and even different countries.

Conclusion. Management practice, while restrictive, does permit and encourage substantial numbers of scientists, and to a lesser degree of engineers, to attend professional society meetings. How many of those who do not attend should be encouraged to do so is not a question this research is designed to answer. It is the opinion of many managers and supervisors that some people will not benefit from attendance and therefore should not be supported in their efforts to do so. Whether managers and supervisors make their judgments as to who will benefit with any high degree of accuracy is still another unanswered question.

As for what people say they get out of these meetings, there is no question that part of the time spent is wasted in listening to papers which have little or no relevance to the individual's work or to papers which, while relevant, may not be of good quality. On the other hand, there is consensus that attending professional meetings is always stimulating, even when it is not productive of specific new ideas which can be applied on the job.

There are many who can cite specific pieces of information or ideas which they picked up and applied either at once or at a later time. These appraisals by research people suggest that the interaction which takes place at professional society and other types of meeting is invaluable for keeping up to date at the frontiers of knowledge. However, it is reasonable to suppose that deriving benefits from these personal contacts as well as from the papers depends somewhat on being already up to date, or at least not outdated. Consequently, those who have fallen behind are perhaps best excluded from this mode of continuing education and should be directed into updating activities.

In-lab Lectures and Seminars

In-lab lectures and seminars provide both information and stimulation to research people through presentation and discussion of the latest developments in a particular specialty, discipline, or field of general interest. (The terms "lecture" and "seminar" are used interchangeably by the people interviewed; the format is that of a lecture followed by discussion from the audience.)

Their purpose is to deal with newly developing directions in science and engineering, and not for updating, refresher, or in-depth learning experiences, that is, in-lab lectures are primarily for keeping people up to date with the state of the art.

Characteristics of Employer Programs. *This mode of continuing education is found in all 17 laboratories*. Thirteen (six industrial, seven government) have regular series of lectures and seminars which are held once a month or more frequently. In the four remaining laboratories, the lectures and seminars are not held on a regular basis and take place less than once a month. In all the laboratories, these lectures are normally given during working hours. Any professional person in R&D may attend these in-lab lectures (consequently, these are hereafter referred to as "open" lectures and seminars). In six (one industrial, five government) of the 13 laboratories holding regular series of lectures and seminars, departmental seminars are also held at least once a month. These are primarily for the staff of the department, although interested members of other departments are also invited or welcomed.

Open lectures and seminars are sponsored by management to serve as a communications bridge between the laboratory personnel and the larger scientific and engineering community, whereas departmental lectures and seminars serve in this capacity for research personnel within a department and laboratory. Both are characterized by the fact that, depending on interest or value, attendance is left to the discretion of the individual professional. This is so because some lectures are of "broad appeal" and others of interest only to persons specialized in a topic at an advanced level. The latter attract relatively small audiences and are usually not suitable for the non-specialist. In order to understand the difference between open and departmental lectures, it is important to know that in those laboratories with regular series of lectures, the lecturer is someone in research from outside the laboratory. Only rarely is one of the open lectures given by a laboratory-employed scientist or engineer. By contrast, departmental seminars are typically given by someone employed in the laboratory and frequently by someone in the same department whose members are attending the lecture.

Characteristics of Those Attending In-Lab Lectures. *Attending in-lab lectures and seminars is one of the most popular modes of continuing education*.

Over three-fourths of the questionnaire sample have attended in-lab lectures in the past two years.[2] Eighty-seven percent of the (231) scientists and 66 percent of the (163) engineers report attending in-lab lectures.

Appraisal by Research Personnel.

1. In-lab lectures and seminars provide information on the latest advances not yet in the literature; thus they deal with the state of the art at an advanced level. As one man put it, "Seminars expose you to future developments." Another said, "Seminars tell you where the answers are going to be coming from."

2. In-lab lectures and seminars provide a guide to where to go for more information by citing the latest sources in the literature and specifying the personnel doing the most advanced work on the topic being discussed. Savings in time and effort are self-evident, even if the information is not put to immediate use. As one scientist put it:

> The series of lectures we have is a pretty good thing, but I don't think this does more than point up to some people where to go to learn more. I don't think you can do more in a lecture. Also, I think to learn a field you have to work out problems and do assignments. Lectures just let you know what is going on. But you have to learn it on your own.
>
> Ph.D., Organic Chemistry, age 51, Supervisor

3. Outside experts serve as a source of stimulation by bringing in a fresh point of view to the laboratory. Outside speakers serve as catalysts in a participant's thinking about his own problem or they provide leads into new ways of thinking not previously considered.

In addition, they reduce the feeling of fear in an individual that he is falling into a rut and losing touch with broader developments outside the scope of his own research. This is reflected in the following comment:

> Three years ago we had monthly colloquia, but not lately. But it was limited to our own work... There should be seminars of general interest in other fields, not so directly work related. (What would be the value of these to you?) To get out of your own field to see what is going on. I'm not interested in limiting myself to one field. You might sometimes get an idea out of a seminar in another field you wouldn't have thought of otherwise.
>
> Ph.D., Physical Chemistry, age 42

4. The existence of an in-lab lecture and seminar series lends an air of intellectual activity to the laboratory. They are said to "warm up" the environment by permitting interpersonal contact and

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[2] We did not obtain the exact number attended. The interview sample indicates that one or two per month is about average.

discussion, thus reducing the frustration of solitary thinking, while at the same time providing an interdisciplinary approach that is always desirable in today's science. The following is an example of how a number of people answered the question, "What are the benefits to you of attending in-lab lectures and seminars?"

> There are two reasons. One, sometimes it's nice to hear the guy who's done it talk about it. You get more information than in a published paper. Science isn't all that abstract that it can all be reduced to equations and technical writing. When you hear a speaker, it's colorful, it comes alive. A lot of information can come out in this manner. Besides, you meet people from other parts of the country working on the same problem you are. (How does this benefit you?) The cross-fertilization of information sometimes.
>
> Master's, Electrical Engineering, age 23

The above points are the principal benefits of in-lab lectures and seminars cited by the personnel participating in the study. In addition to making these points, people also recognize, for the most part, that in-lab lectures are not intended to take the place of course work and are not suitable for refresher or updating purposes.

Conclusion. In-lab lectures and seminars are one of the most available and most used of the employer-sponsored modes of continuing education. Managements tend to rely on this method more than others for bringing all levels of laboratory personnel into contact with other scientists and engineers outside the laboratory. There are almost no restrictions (and none by policy) placed on attendance; attendance is left up to the individual. (Only the demands of the job or an unusually restrictive supervisor would actually prevent anyone from attending who wanted to.) Consequently, a majority of scientists and engineers have attended them. However, those who were interviewed indicated that they are selective in their attendance: they go only if the topic is one of interest to them -- interest which ranges from intellectual curiosity to anticipated applications to their own work.

The value of in-lab lectures to R&D personnel is both in the information which can be obtained from listening to other research people talk about their work and in the stimulation derived from exposure to fresh points of view and new ideas. The extent to which this stimulation and motivation leads directly to further continuing education studies is unknown; we can only say that some of the people interviewed claim that it has led them to undertake further reading or discussion with colleagues on the ideas presented in a lecture they have attended.

Leaves with Pay

Because of their long-term nature, usually of one year, leaves with pay serve as a reorientation of the individual, whether it involves refresher and updating experiences, shifting of focus in research, or upgrading of potential. Two major types of leave with pay are granted in the laboratories studied:

> 1. Sabbatical leaves, which enable mature researchers to break away at some point in mid-career and expose themselves to the stimulating and broadening effects of an altered environment. These leaves are primarily for refreshing and updating and may involve diversification into new fields which are extensions of past research interest.
>
> 2. Educational leaves, which are used to facilitate work toward a degree, such as fulfillment of course requirements and/or preparation of a dissertation. These leaves are primarily for upgrading and not for continuing education purposes of refreshing, updating, or keeping up to date.

As we have indicated elsewhere in this report, degree-seeking activities are excluded from continuing education as used here. However, it is of some interest to contrast what managements do in the area of educational leaves with policies and practices with respect to sabbaticals.

Compared to other modes of continuing education, sabbatical leaves with pay are the least used mode; management supports fewer people on sabbatical leave than in any other mode of continuing education. R&D scientists and engineers who take sabbaticals have one or both of two objectives: they intend to engage in a comprehensive program of study to update and refresh themselves in one or more of their fields of specialization; and/or they intend to engage in research in collaboration with, and for the purpose of learning from, a distinguished researcher in some laboratory or university other than their own employer. In spite of being least used among the modes, sabbatical leaves are regarded by both the management and R&D personnel interviewed as the most comprehensive way of obtaining in-depth updating and refreshing in a field of specialization. They are also an excellent way of obtaining diversification into new fields of interest (an objective which educational leaves for a degree also serve).

Laboratory Policies and Practices. The most significant thing about management policies on sabbatical leaves with pay is that they are not written, there are no fixed rules for eligibility, and applicants are not actively solicited. Only one written policy on sabbaticals was obtained from the laboratories which grant this type of leave. Reasons for this lack of written policy are explored below; what they add up to is that the costs are such that management supports only a very small number of people on sabbatical leave, is very selective about who is supported, and, therefore, does not actually need written policies to implement this amount of support.

1. Leaves with pay are the most expensive mode of continuing education per man. One laboratory estimated a sabbatical leave costs approximately $25, 000 per man going to Europe, somewhat less for a man remaining in this country. Another estimated $20, 000. Precise figures on costs could not be obtained, because most laboratories charge tuition to one budget (if any) and travel to another, while salary simply continues out of the regular pay roll. In addition to these more or less calculable out-of-pocket costs, leaves involve other, less direct, costs.

2. All the laboratory managements cite the problems which a man going on leave causes for them by the loss of his productive work effort. He is not replaced, and if work is dependent on him alone, it is not done in his absence. Top management reports that some of its members and other managers and supervisors are reluctant to have men go on leave for this reason. The greater the pressure to meet deadlines and commitments, the more likely this is to be a deterring factor both for the man and for his supervisor.

3. The number of persons supported on leaves is quite small relative to the total R&D work force employed. In government laboratories, the actual number of persons supported on sabbatical leave ranges from one to ten; in industry from one to six. In both cases, these figures represent less than two percent of the R&D work force. (See Table VI-2.)

Table VI-2 shows that granting of sabbatical leaves is a more universal practice among government laboratories than among industrial laboratories.

4. By contrast, in both industry and government, more than twice as many people are supported on educational leaves to seek a degree than are supported on sabbatical leaves. Again, educational leaves are more universal in government than in industry. (See Table VI-2.) For educational leaves, in government the range is from four

to 25; in industry only two laboratories support any on educational leave (six and 50 respectively); in both industry and government this works out to less than two percent of the work force in any one laboratory.

TABLE VI-2

ANNUAL SUPPORT FOR EDUCATIONAL AND SABBATICAL LEAVES WITH PAY

PERCENT* BY TYPE OF LEAVE		Government N=8 Labs	Industry N=9 Labs
Sabbatical:	0.5% or less	3	3
	0.6 - 1.0%	3	1
	1.1 - 1.5%	1	-
	1.6 - 2.0%	-	1
	Not Granted	1	4
	TOTAL	8	9
Educational:	0.5% or less	1	-
	0.6 - 1.0%	1	-
	1.1 - 1.5%	3	-
	1.6 - 2.0%	2	2
	Not Granted	1	7
	TOTAL	8	9

*In two of the laboratories, the policy on leaves with pay applies to a larger organizational unit than the central R&D laboratory studied. The larger work force is used as the base.

5. Also by contrast, management policies on educational leaves are generally written and formalized with rules governing eligibility and other matters. Such written policies were obtained in all the laboratories which grant educational leaves. In practice, educational leaves are limited primarily to those younger staff members who are judged to have the greatest potential for work at a higher level but who are currently hampered by lack of requisite training and degrees. The extent to which an individual has already taken university credit course work toward a degree is also considered in granting educational leaves.

6. Management is very selective about who goes on sabbatical leave. Although there are no fixed rules for eligibility, and applicants for sabbatical leave are not actively solicited by management, there are rules of thumb which are used in judging whether an individual requesting sabbatical leave should be given it. These are: a) demonstrated high-level research competence and productivity, b) five to ten years of service with the laboratory, and c) a proposed plan for use of sabbatical time which is relevant to the laboratory's present or anticipated future interests or needs. This is the way one top manager expressed the prevailing thinking in all the laboratories granting sabbaticals:

> His supervisor and manager evaluate the individual's potential and his performance. It would not be a new man. He would have to have five to seven years at the laboratory. He would be of a scientific bent and definitely not management-oriented. He would have published extensively. He would be a scientist's scientist.
>
> Ph.D., Organic Chemistry, Top Manager

Almost all the examples cited by managements of men on sabbatical leave were located in universities, about half of them in European universities or research centers connected with European universities.

7. Top managers also state that they rarely actively solicit personnel to go on leave. The initiative is left to the individual to bring up the possibility of a leave for himself and to show how it would benefit his research. Only infrequently does management solicit someone to go on leave to acquire capability or training needed by the laboratory's mission. Consequently, there are many people in these R&D laboratories who do not know there is an unwritten policy on sabbatical leaves. Quite the opposite is true of educational leave policies; most of the people interviewed knew of the existence of these policies and accurately understood their requirements and provisions.

Management Appraisal of Leaves with Pay. Top-management people say that their sabbatical and educational leaves with pay are of significant benefit to both the individual and the laboratory. One industrial manager expressed the prevailing attitude about sabbaticals as follows:

> If a man wants to go into a new field and he goes to an expert to work with him in his lab, the expert is glad to have him. After all, we are paying the man's salary and some part of his living expenses and the expert has a high-quality assistant for a year that he probably couldn't afford or even find to hire. So the expert is happy and we are happy to have our man trained by him. There is also the man who goes to an expert in a university to study for a year without doing research.
>
> Ph.D., Organic Chemistry, age 44, Top Manager

Another top manager commented:

> These sabbatical leaves are frequently taken for the purpose of working in the laboratory of a distinguished scientist in a university. It is a great idea for us to have a man go in these circumstances because of all the knowledge these people pour into our man which he brings back to his work here. And, of course, the university professor benefits by having a top-quality scientist working on his problems for a year at our expense.
>
> Vice-President of Research, Industry

In addition to evaluating sabbaticals favorably, top management people think that there should be a greater number of people on leave than they are presently able to support. How much greater this number should be is not known, nor do top managers have any good guesses as to what it should be. However, both costs and loss of productive work time previously discussed are given as the reason why the number going on leave is not likely to increase significantly in the near future.

One concern which top managers voice about granting leaves is the risk of losing the individual when the leave is over, and the risk differs by the type of leave. On the basis of their own experience, top managers say men on sabbaticals usually return because:

1. They have a high level of commitment to the work in which they have engaged prior to their sabbatical and this draws them back, and
2. They are usually long-service employees, which reinforces their desire to return.

On the other hand, managers say that the loss of men on educational leave is more noticeable. However, only two laboratories have developed any facts to back up this impression. Both have concluded that the educational leave programs benefit the laboratory and make the cost acceptable in spite of some attrition.

Employee Appraisal of Sabbatical Leaves with Pay. Sabbatical leaves with pay were discussed in the interviews by a great many more people than have actually been on leave. Eight of the persons interviewed had been on sabbatical leave, and approximately eight more were planning to go in the near future. An additional 21 scientists and engineers in the questionnaire sample had been on sabbatical leave.

The idea of a sabbatical leave is very attractive to R&D scientists and engineers in the abstract, in spite of some of the concerns and anxieties it arouses. Its attractiveness seems to stem from its correspondence to the academic practice of using sabbaticals and from the imagined or experienced benefits derived from going on leave. The anxieties stem from the need to uproot the family (and oneself) and the risk of not being present when promotions and other opportunities arise.

The research people who have been on sabbatical leave agree that the experience was very valuable and of benefit to them both as a learning and as a refresher experience, and very often they become enthusiastic supporters of sabbatical activities for others. For example:

> I was fortunate in having an opportunity to spend a year at the University of Zurich. I found that to be very worthwhile. However, this has been on an individual basis. There is no established program. An established program would provide an incentive for people to look forward to and would be more widespread.
>
> Ph.D., Physics, age 36

And another man said:

> I was a test case in the sabbatical program. Since I spent a year in a university in Europe we have had one or two senior people every year since then who have gone to universities outside the United States. This is a good system because this is related work. You are dealing with productive people and giving them a new environment so that they can get a different perspective, and they also can pick up new skills. I think this should be made a formal thing without hiding it as we do now.
>
> Ph.D., Physical Chemistry, age 41, Supervisor

Both of these men (and others as well) are unaware of the existence of an established but unwritten sabbatical policy in their organizations. This reflects the lack of publicity given to sabbatical leave policies.

Several men were interviewed who were planning to take a sabbatical leave in the near future. Like those who have been on leave, they expect to derive definite professional benefit from their year away.

> I work in the field of optics. I got my Ph.D. in 1949. The subject of optics has undergone quite a renaissance. To some extent directions have changed. There is a whole area of what might be called "modern optics." These subjects didn't even exist at the time I did my graduate work. Since I am responsible for a group of 20 people in which there is developing a set of problems related to these areas, I began to feel a deficiency

> on my part relative to my knowledge, background, and experience. The press of administrative work gets to the point where it's very difficult to find adequate time to become familiar with these things except in a very superficial way. I began to feel this deficiency. I analyzed my own situation and decided what I needed was time and an externally imposed discipline. This led to my present decision, which is to leave here for a year on a sabbatical program. I had two choices for this year. One was to take a year in involving myself in some experimental work. But I decided not to do this. I need to pick up the theoretical basis. I have laid out a program of study in a university environment where I can expect to find the discipline that goes with lectures. I will work in collaboration with a man who is well known in the field of modern optics.
>
> Ph.D., Physics/Optics, age 45, Supervisor

This same man reports that he encourages his people to take short courses and sabbaticals because of the refresher aspect of being away from the laboratory for awhile.

There are three barriers to taking sabbaticals which were cited by people discussing them which shed light on some of the anxieties felt by individuals going on leave. These are:

1. Potential disruption to family life will cause a man to hesitate to go on leave. However, if the family accepts the change, a sabbatical becomes much more attractive. One chemist replied to the question "what would a sabbatical involve for you" as follows:

> My wife and three kids have to move. We have to rent or lease the house. We will be meeting new people. (Does your family look forward to it?) Yes. We have several friends who have moved a great deal, all the way from Brussels to Singapore. My kids know people do this. Lots of people transfer. I think they're curious what it will be like. I wouldn't even consider it if my wife didn't want to do it. My children, when they say no to something, they don't have deep insight and I don't pay any attention to them. If I thought it would cause problems for them, I wouldn't do it.
>
> Master's, Chemistry, age 33

2. Disruption to work is a more severe deterrent. Several people stated that the work they are doing would cease if they left for any period of time, as they were the only ones doing it. One engineer who vetoed the idea of a sabbatical for himself said:

> No, I would hate to leave my work for that long. (What would a sabbatical do to your work?) It would fall on its face. I am the one responsible for carrying it through because there is a shortage of personnel. It's brand new for this laboratory, and I was chosen at the outset to follow it. We are now involved in considerable R&D effort, and I'm still the only one involved in it.
>
> Bachelor's, Engineering Physics, age 33

3. The risk of being away when organizational changes occur, and consequently not competing actively for any opportunity for promotion that may arise, was cited by several men. These three kinds of anxieties represent psychological barriers to taking sabbatical leaves.

The Expressed Need for Leaves with Pay. As reported in Chapter IV (Table IV-4), 11 percent of the researchers answering the questionnaire cited a need for educational leaves with pay or other financial support while attending school because they cannot afford to seek an advanced degree without it.

On the other hand, there is very little mention of a need for sabbatical leaves with pay. In part, this may be a result of the semi-official silence about policies on sabbaticals. Since sabbaticals are not widely publicized, interest and aspirations may not be aroused. It may also be that the personal concerns cited in connection with leaves are widespread, and thus sabbaticals are not highly desired by large numbers of people. An alternate explanation may be that since there is a scarcity of sabbatical opportunities, most people do not regard them as a potential opportunity for themselves. In any case, in spite of their attractiveness in the abstract, there is very little spontaneously expressed need for them.

Conclusion. Sabbatical leave with pay is a mode of continuing education which has the distinctive function of giving a researcher the opportunity for revitalization and reorientation. As a mode of continuing education, it is limited to a select few productive and senior research people; it is not designed for, nor expected by, the majority of personnel in R&D. Because of its high cost per man and the loss of his productive time while on leave, top managements do not anticipate that it will become more widely available in the near future.

However, the managers, scientists, and engineers who have been on leave, and those who hope to go, all say that sabbatical leaves with pay are of significant benefit to the laboratory as well as to the individuals.

Summary and Conclusions

Two of the three modes of continuing education presented in this chapter -- professional meetings and in-lab lectures -- have the distinctive function of helping people keep up to date with the state of the art in their fields of work.

These two modes are unlike university credit courses and in-lab courses in that neither is particularly well suited for the person who is already out of date and behind the times. To make best use of attendance at professional meetings and in-lab lectures, an individual must not be obsolescent in the topics which are discussed or presented, since the presentation assumes current knowledge of its subject-matter context. This is especially the case for short papers at professional society meetings and for in-lab lectures.

Sabbatical leaves also help people keep up to date, but they do much more. Sabbaticals are generally taken for the purpose of getting caught up in great depth in areas in which the individual is already working, or for the purpose of pursuing a new or related line of research by studying with a senior colleague in another laboratory or university. In either case, there is no sharp break with the individual's past but a diversification as well as updating based on prior research and training. Sabbaticals result in revitalization and reorientation of the individual; the result is very much a recharging of the individual's potential.

Each of these three modes has a different range of availability. Management makes sabbaticals available only to a few of the most productive and highly-valued senior scientists and engineers; a substantially larger number are supported in attending professional meetings, although many junior-level people are not supported in this mode; and in-lab lectures are available without restriction to almost any R&D professional who cares to attend.

To a considerable extent, the modes used depend on which are available. The question arises of whether or not a greater number of junior-level personnel should be supported in attending professional society meetings. This research does not provide an answer to this question but suggests that managements should reconsider their practices in light of the potential which professional meetings have both for information acquisition and for stimulation and motivation to carry on with research.

The issue can be stated in a more generalized way. This research shows the value of interaction with colleagues -- five specific objectives of interaction have been identified, and interviews indicate that all of them are important to at least some research personnel. We recommend that managements and others interested in furthering continuing education provide these forms of interaction with colleagues to R&D people at all levels as a source of information and stimulation. Professional societies, universities, and colleges can play a strong part in providing these opportunities. Local chpater meetings of professional societies and university-sponsored seminars are equally good for obtaining these kinds of contacts as in-lab lectures or national or regional professional society meetings. Furthermore, local meetings are more accessible to larger numbers of people and do not necessarily involve loss of productive work time. From the very limited information available, the impression exists that local chapters of professional societies can plan an integrated series of lectures on the state of the art in a scientific or engineering field. They might even be able to do so more readily and with greater satisfaction to the local members than managements can. As pointed out in Chapter I, there are a number of engineering societies which have prepared guides and other aids for doing this. The American Chemical Society program is too well known to recapitulate here, but it certainly can also serve as a model for other professional societies.

CHAPTER VII

SELF-TEACHING MODES OF CONTINUING EDUCATION

The three modes of continuing education presented here -- reading, teaching, and journal clubs -- depend heavily on individual efforts and inner motivation. They differ from those presented in the preceding two chapters in that they are not employer-sponsored.

Reading the Literature

Reading the scientific and technical literature is the most used, most emphasized, most frequently mentioned and highest-ranked mode of continuing education. As reported in Chapter IV, 68 percent of the scientists and engineers questioned ranked reading the literature as the most important mode of keeping themselves up to date. An additional 17 percent ranked it second. Thus, a total of 85 percent rank reading the literature as either first or second in importance in keeping themselves up to date. (See Table IV-3.) No other mode is so important to so many of the research people. (There are no significant differences in these figures between scientists and engineers, industry or government employment.)

Scientists and engineers report that keeping up with the literature is a burdensome and frustrating process because of the sheer quantity of material published. If, in addition to one's own field, one tries to remain current with ongoing developments in allied or adjacent fields or in other fields of interest -- and many scientists and engineers believe this is something they should do -- the task becomes virtually impossible. For example:

> It's impossible to keep up with the literature. The amount of knowledge can't be assimilated. In order to cope with the literature, you keep narrowing it down. Even then, it's impossible and still do your job. I rationalize that others are in the same boat, so none of us can keep up, so I don't have to worry too much.
> Master's, Biochemistry, age 33

Patterns of Reading the Literature. In the view of the R&D scientists and engineers who were interviewed, work-related reading is work; it requires concentrated attention in order to absorb new material, and it may take considerable time to absorb just one journal article. Work-related reading is also essential to keeping abreast of the state of the art and being informed of new developments, trends, and experimental findings which pertain to work. For example:

> In order to do any sort of creditable job in research, a person has to read the literature. In doing that, he is, in effect, educating himself. Also, the way we operate here, a man works on a particular problem for an average of two or three years and then moves on to something else. The new problem may be unrelated to what he worked on before. So he has to develop a new background. This is continuing education in order to do the job properly. The nature of research requires it. Without it a person couldn't last more than about a year without his supervisor being aware that he isn't doing a good job. The quality of the work he does is reflected in how well he has educated himself in this area. He couldn't get by for long without at least reading the literature.
>
> Ph.D., Organic Chemistry, age 34

> A person can get a lot of what he needs just by reading. You got to do this. If he doesn't read journals extensively, he'll be lost in two or three years. ...An organic chemist needs to take a course every two or three years too. But he needs both course work and reading, especially review articles. That is how you keep up to date in your field.
>
> Ph.D., Organic (Plant) Chemistry, age 61

While researchers focus their reading primarily on the literature pertaining to their work, some supervisors state they must read widely in the literature pertaining to all the assignments they supervise. However, they do not have to keep on top of experimental results so much as on trends and developments relating to the fields of work they supervise.

Reading loads are reported to be heaviest at initial stages of a project, prior to setting up experimental work or in preparation for a new assignment. For example:

> We keep switching interests so often, actually formal education wouldn't be of great advantage. If you are going to be in starch research continuously, then you could learn all about that. But three years is about it for us. The first six months you try to find out in the literature what you need to know about your assignment. Then the rest of the time is putting it to work. (Is this switching satisfactory to you?) Yes, it's very stimulating. You are exposed to a lot of different facets of engineering, biology, and chemistry.
>
> Bachelor's, Chemical Engineering, age 55

The interview data also suggest that research scientists rely more heavily on journal literature, whereas design and development engineers in R&D who deal directly with practical applications rely more on other sources, such as technical trade magazines. One engineer put it this way.

> The practical aspects of the research are completely glossed over in the scientific journals and little consideration is given to them. So the bulk of the knowledge in literature which most practicing engineers use comes from technical magazines.
>
> Bachelor's, Engineering Physics, age 30

Because of the massive and steady outpouring of literature, reading is not a postponable process. One chemist summarized this point as follows:

> I have a good memory. I see about 20 journals a month and read six regularly. I also read new books, review books, two or three a year. I'm fairly up to date. I've done it myself through reading, I haven't taken any formal courses. The problem is -- if you create a break, you can't recover from it. Keeping up with the literature is an irreversible process; when you make the break, your whole attitude changes.
>
> Ph.D., Organic Chemistry, age 33

There are some scientists among those interviewed who read new textbooks in order to keep up to date with changes in their own field and to obtain an integrated and systematic overview of allied or adjacent fields. However, this reading is not seen by them as a substitute for reading the journal and other scientific literature. Textbooks provide a systematic coverage of a subject and, if it is a relatively familiar one, can be read by the research person without too much difficulty. However, textbooks are not considered to be as up to date as the journal literature, itself always somewhat dated by the time it reaches print. (This is the reason that interaction with colleagues through meetings and personal acquaintance is so necessary.) For example:

> I read textbooks too. Not generally for keeping up to date. But I'm involved in some work not related to lipids, the field I've been in for ten years. I'm working on some juice without lipids so I have to go back to textbooks for material I am no longer familiar with. I also read some texts in instruments, NMR for example, which we have occasion to use. NMR would be run by someone else in the building, but we should be aware of its potential. And it helps you to better understand some of the scientific papers which are quite current if you have the background from a textbook. On other occasions, I read a text to see if I have overlooked something in the literature. The annual review of biology is a book I

> survey. It covers a year's literature and comes out three or four months after the past year.
>
> Master's, Chemistry, age 34

> I read the literature only in my speciality. I read the *Journal of Chemical Education* and *Scientific American* also. The *Journal of Chemical Education* is aimed at teachers, not researchers. So it's review. It organizes the details for you. I read abstracts for my speciality, *Chemical Abstracts*, *SPSE*, *Royal Photography in England*. I also read textbooks. A textbook may be two or three years behind the times, but it is not eight years behind. Reading a textbook you see different points of view. You see things presented as a whole development. It is interesting. But I read research reprints only in my speciality because that is all I can fit in.
>
> Bachelor's, Photographic Chemistry, age 31

In short, scientists and engineers in research find that reading is a problem because of time, but they still manage to devote an average of about ten hours per week to work-related reading on the job and at home. They tend to emphasize reading the journal literature and technical magazines and say there is so much of it they do not think they do a good job of covering all they should. However, their reference is rather generalized, and what they mean is that they do not do all the reading that they think would be desirable. Whether or not they would realize appreciable benefits on the job from spending more time in reading is somewhat debatable. At the present, the absolutely necessary reading seems to be done.

An additional problem is cited by those who lack the mathematical background to understand the current journal literature. Being able to read and understand the journal literature requires being up to date in the concepts, language, and theory on which research articles are based. Those who are falling behind in the underlying theory, and in the mathematics which is the basis for much of the current literature, report difficulty in reading scientific journals. This is one of the reasons scientists and engineers so frequently mention a need for refreshing and updating in mathematical subjects (see Chapter I). Previously, in discussing in-lab courses in Chapter V, we brought out the need for such courses in mathematics -- there we emphasized the need for preparation to take other courses possibly in a university. Here, we wish to emphasize the need for understanding the mathematics on which much of the current literature is based.

As mentioned in many of the quotations already cited and throughout the interviews with scientists and engineers, there is a tendency to narrow the scope of one's reading, to bring it into focus with one's research tasks. General reading which goes beyond this takes second place, yet there does seem to be a need for these people to keep abreast of scientific developments beyond their own field. While this is more a matter of interest than a need stemming from the work situation, it may very well be an essential part of a researcher's life. For example, there is considerable emphasis on reading, for pleasure as well as interest, of general science magazines, such as Scientific American and Science.

R&D scientists and engineers also make considerable use of short-cuts to the literature: abstracts, indexes, bibliographies, information retrieval output, documentation centers, recent textbooks, and review papers. All of these are found useful. Throughout the interviews, R&D scientists and engineers repeatedly stress the need for more review papers than they now have available in the literature they read. The advantages of review papers are discussed in Chapter VI. While these are a very desirable aspect of professional meetings, on the whole, people want to read them as well as listen to them. By reading they can reflect on, and mull over, the material to a greater extent than is possible while listening. R&D people also indicate that along with the shortage there is a time lag in the appearance of review papers. As one man said:

> The library here serves us well. I try to set aside some period in the week to sit down there and chew over a subject quite a bit. And keep an eye out for good reviews at the same time. There are not enough review papers. There are gaps. Of course, you have to have a fair body of work in the literature before anyone can review it. You may wait five years for a good review.
>
> Ph.D., Organic Chemistry, age 40

It would appear that there is a real need for the professional societies and other publishers of scientific and technical literature to give greater space and emphasis to this type of paper.

Time Spent in Reading. Table VII-1 shows the distribution of hours per week spent in reading work-related scientific and technical literature on the job and at home. The medians indicate that 50 percent of the R&D scientists and engineers spend about four and one-half or fewer hours in work-related reading

3

on the job. The other 50 percent spend four and one-half or more hours reading on the job. The distribution of amount of reading of work-related literature at home is similar.

TABLE VII-1

AVERAGE NUMBER OF HOURS PER WEEK READING WORK-RELATED SCIENTIFIC AND TECHNICAL LITERATURE ON THE JOB AND AT HOME

NUMBER OF HOURS	On the Job N=394 %	At Home N=394 %
None	3	-
One	6	13
Two	11	16
Three	7	9
Four	17	13
Five	15	9
Six	7	6
Seven	2	2
Eight	9	4
Nine or More	22	27
No Answer	1	1
TOTAL	100	100
Median Number of Hours	4.5	4
Average Number of Hours	6.5	3.5
Standard Deviation	5.8	3.7

Table VII-2 shows comparable distributions for number of hours spent reading general (non-work-related) scientific and technical literature on the job and at home. Taken together, these two tables indicate that the average R&D scientist and engineer spends about 19 hours per week reading the scientific and technical literature. A little over half of this reading is work-related, and the remainder is reading for general interest in science and technology.

TABLE VII-2

AVERAGE NUMBER OF HOURS PER WEEK READING NON-WORK-RELATED SCIENTIFIC AND TECHNICAL LITERATURE ON THE JOB AND AT HOME

NUMBER OF HOURS	On the Job N=394 %	At Home N=394 %
None	20	6
One	21	7
Two	23	14
Three	8	5
Four	9	11
Five	7	12
Six	1	8
Seven	1	2
Eight	3	7
Nine or More	6	27
No Answer	1	1
TOTAL	100	100
Median Number of Hours	2.5	4.5
Average Number of Hours	2.5	6.25
Standard Deviation	3.2	5.1

These figures on numbers of hours may seem surprisingly high to some readers; it is possible and even likely that people (including the respondents) over-estimate or exaggerate the number of hours they spend reading. It is elementary psychology to suggest that people will remember periods of heavy reading and "not notice" periods of light reading. In addition, some of the scientists and engineers do not have "average" weeks very often, which adds to the difficulty of accurately estimating time spent in an activity. Finally, a few of them spend the majority of their work week reading for work purposes; some of these are supervisors. In any case, there are no significant differences in the figures between scientists and engineers in number of hours spent reading the literature on and off the job.

Use of the Library. With all this emphasis on reading, the library is obviously an important potential resource. All 17 laboratories have libraries. Their size varies from as few as 9,000 to as many as 250,000 bound volumes. Some of the characteristics of these 17 libraries are described in Table VII-3.

TABLE VII-3

CHARACTERISTICS OF PARTICIPATING LIBRARIES

CHARACTERISTICS	Size by Number of Volumes			
	Under 25,000 N=6	26,000 - 50,000 N=5	Over 50,000 N=6	Total N=17
Budget	$ 75,000 - $500,000**	$ 48,000 - $350,000***	$400,000 - $700,000***	
Staff	1-6	4-80	10-42	
Journal Subscriptions	300 - 1,000	600 - 1,100	800 - 1,820	
Special Services				
1. Bibliographies	3	3	5	11
2. Abstracts	2	2	3	7
3. Periodic Abstracts	-	2	2	4
4. Translation Service	-	2	4	6
5. Accession List	1	1	3	5
6. Information Retrieval	1	1	3	5
7. Information Bulletin	-	2	2	4

**Budget information not available in 3 libraries.
***Budget information not available in 2 libraries.

Those libraries which have large staffs include in their count persons working in some highly specialized services, such as a bindery or documentation center, and providing other technical information services not usually a part of a library. Table VII-3 also lists the special services provided by some of these libraries. All of the available services are used by the scientists and engineers; librarians state they are used to their capacity to provide them. However, as will be shown, not every R&D researcher uses the library equally or in the same manner. In addition, the laboratories in the Department of Defense have available the services of the Defense Documentation Center in Washington, D.C. which provides information retrieval services on documents deposited there. There are also a number of subscription services to information retrieval services in the sciences which some of these libraries buy for their laboratory's use.

Although 98 percent of the scientists and engineers report that they make some use of the library, the extent of use depends on how the individual views it as an up-to-date resource, the amount of time he has available for its use, as well as his own motivation and interest, and the distance it is from his place of work.

The questionnaire contained one direct question on use of the library, and five possible responses -- the first four are uses, the fifth indicates non-use. The research people were allowed to check as many of these responses as they thought applicable to themselves. Table VII-4 shows the percent checking each of the five responses. In addition, researchers completing the questionnaire were asked to write a short statement explaining their answer, if necessary, or elaborating on their use of the library. Less than half actually wrote a statement. Use of the library was also discussed with those who were interviewed. What follows is an analysis of these data and of the correlations of other variables with the five responses to this question.

As shown in Table VII-5, the most common pattern is to use the library for all four, or for three of the four, uses listed in the question. Only 25 percent confine their use of the library to information needed on their current research problems and assignments (#2 and #3). These latter people tend to be engineers and/or to be under pressure from work.

> I use the library primarily for books. I only come down here if I have a specific question. I look at all the books on that subject. This library has a document section. I use that a great deal. . . . I also go through abstracts I get. There is not enough time to browse through the library and with the abstracts I get I don't have to do that.
>
> Bachelor's, Engineering Physics, age 33

TABLE VII-4

USE OF THE LIBRARY

I use the library:	Percent* N=394
(1) As a source of intellectual stimulation and new ideas for my current work.	58
(2) To keep myself up with the literature about problems I am currently working on.	80
(3) As a source of specific facts and technical information I need to have for my current assignment.	93
(4) To keep myself up generally with current ideas and knowledge in fields of interest beyond my current work.	80
(5) I do not depend on the library for any of the above.	2

*Percents do not add to 100 because this is a multiple-response question.

> I used the library the first two years I worked here. But the work is getting less diverse, and now things are so large that we each have our own portion. I am concentrating on landing problems, what the pilot can see and what he cannot see. The library is outdated for that. I get information direct from the experiments.
> Bachelor's, Aeronautical Engineering, age 27

The others, those who use the library for purposes beyond their work (#1 and #4), tend to be scientists, to use several modes of continuing education, to have several fields of specialization, and to work in groups composed mainly of Ph.D.s. They also report considerable autonomy in setting their own work goals in research. In addition, these people have published several papers and regularly attend professional meetings and in-lab lectures, and regard these two modes, along with reading, as important in keeping themselves up to date. In sum, these users of the library are productive workers and engage in continuing education activities which expose them to the ideas of others, both through personal contact and through reading widely in the literature beyond their current assignment. This array of correlations with library use beyond the current assignment (#1 and #4) suggests that exposure to the ideas of others (meetings,

TABLE VII-5

OVERLAPPING PATTERNS OF USE OF THE LIBRARY

PATTERN OF USE*	Subtotal N=394 %	Total N=394 %
Broad Patterns		
Use for all purposes #1 through #4	43	
Use for some combination of three purposes out of #1 - #4	29	
Subtotal		[illegible]
Limited Patterns		
Use for purpose #3 only	12	
Use for purposes #2 and #3 only	13	
Subtotal		25
Do Not Depend on Library (#5)		2
All Other Patterns		1
TOTAL		100

*See Table VII-4 for specific uses.

lectures, working with Ph.D.s, etc.) is quite important in motivating those most active in continuing education. This reinforces the previous findings on the importance and function of reading as well as of the interaction modes reported in Chapter VI. For example:

> It is absolutely necessary to read some journals. And in line with that, attend some meetings, not for papers but for meeting people. By keeping in touch with these people, you know where the answers are going to be made. That's why I brought this up. By reading and meeting, you can find out who is doing the important work in your field, and you can keep in touch with them every six months or so and find out how they are doing and when they are going to publish. That helps a lot in keeping you up to date in your field. Otherwise, as far as just following the literature by trying to keep in touch with those journals which are likely to have material in which you are interested -- I find it impossible. (Why?) Sheer quantity. I have other things I have to get done besides.
>
> Ph.D., Chemical Engineer, age 43

> It is no longer possible to advance and remain productive without continuing education. It depends on what your goal is, of course. But in some way you have to study something in one way or another. (What are the best ways to keep up to date?) The best is reading the literature. Number two is meeting people who are knowledgeable in the field and talking to them. At my level courses are not too useful. If you are going to pick up a new branch of your discipline, a course would help. But, in my opinion, at this level courses do not usually help because they are either for beginners or for those changing disciplines.
>
> Ph.D., Physical Chemistry, age 41

This analysis suggests that the library is an important, even necessary, resource for R&D scientists and engineers who wish to keep themselves up to date. The library not only houses the literature and keeps track of it but in many instances provides special services (see Table VII-3). These special services may stimulate and motivate personnel to some extent by providing short-cuts to the literature (e.g., reducing the volume of material which must be personally inspected).

Journal Clubs and Grass Roots Seminars[1]

Journal clubs are voluntary, informal associations of small groups of scientists organized without higher-level management initiative or support, but may include working supervisors one or two levels up from the bench. The purpose of the journal club is to split up the literature on a topic, have each member read some of it, and report to the others in summary form. Other similar associations for the purpose of discussing research problems of mutual interest (and perhaps also the relevant literature) are informally referred to as "seminars" by some of the people interviewed.

Journal clubs were found in four of the participating laboratories (two government and two industrial); grass roots seminars in three (all government). Twenty of the 205 men interviewed report having participated in one or another of these two types of group. Both these types of association are composed primarily of scientists, not engineers. We also have the impression that these scientists are the more theoretical and more discipline-oriented rather than mission or product-oriented scientists.

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[1] When this study was planned and the questionnaire designed, journal clubs and informal seminars of this type were not anticipated as modes of continuing education. Once we became aware of them, we asked about them in the course of the interviews. However, available information is limited and was not systematically collected.

Journal clubs and grass roots seminars function as an instructional and communication medium. For example:

> We have a journal club that meets right here in this room, and each person covers something from the literature. It's half an hour every two weeks. We are aware of other things and other people's interest in that way. It's voluntary. Mostly the young ones want to have these. A few of the old-timers come, but quite a few don't care to come and participate.
> Ph.D., Pharmaceutical Chemistry, age 31

The purpose of having these journal clubs as stated by those involved in them is (1) to share the burden of covering the literature on a problem, (2) to exchange information and ideas on the literature as it pertains to current assignments, and (3) for the stimulation and motivation which results from interaction with colleagues. Thus, these journal clubs and grass roots seminars facilitate and encourage interpersonal communications on technical matters generally. One man who started a journal club explains his reasons as follows:

> Professionalism in my group is virtually non-existent. I think that one of the reasons we don't have professionalism of attitude is the lack of professional and interpersonal interaction. You just don't have any. This is a mistake. It's only through discussion with other people that I start getting interested, and it makes tomorrow a day worth looking forward to.
> M.D., Space Medicine, age 29

Journal clubs, grass roots seminars, and teaching appear to have great potential for continuing education. It is surprising that these modes are not more widely used. Management perhaps should take the initiative to a greater extent than it does in fostering the desire, and providing the opportunities, to engage in these modes. While they may be of value primarily to scientists and Ph.D.s, there is little or no apparent reason why they should not be further exploited in continuing education. These modes also need to be studied further in future research.

Teaching

Teaching is considered by those research engineers and scientists who engage in it as a very important part of their continuing education, because:

1. Preparation for teaching requires knowing the current state of the art and how it is being taught by others, and this involves extensive reading of the literature and textbooks.
2. Teaching requires logical organization of material and a broad view of its applicability, thus serving a refresher and updating purpose.
3. Review serves to reveal relationships in a different light than they appeared when the teacher previously studied the subject.

The basic motivation to teach is reported to be the enjoyment and satisfaction that comes from the experience of seeing students learn the material presented. However, those who teach are also very enthusiastic about it as a mode of continuing education.

> I teach a lab course in physics at (a nearby) college one night a week. I'm a chemist, and it gives me an opportunity to learn physics. It's somewhat of a challenge. I pick up a lot of electronics. Also, it gives me all the trappings of academic life. I also teach here in the lab, a course in radiation physics. I do that to gain contacts and to learn, but it's a grind. I take every opportunity to teach.
>
> Ph.D., Nuclear Chemistry, age 40, Supervisor

> The way things are around here, my job allows me to generate some ability in a person or persons who are handling certain areas of the job. It allows me to train people. I enjoy that. It's phenomenal how much you yourself learn because you have to anticipate questions and problems. You have to try to read ahead. Training others is a very important educational process.
>
> Bachelor's, Optics, age 30

The questionnaire data indicate that 28 percent of the scientists and engineers have taught one or more formal courses, seminars, or workshops in the past five years. If we exclude those teaching only once in the past five years, the over-all percent drops to 14 percent teaching two or more courses, seminars, or workshops. This represents 41 scientists and 13 engineers. Thus, use of this mode is more frequent among scientists but over-all is relatively limited in use.

Management Appraisal of Teaching. None of the managements in the study deliberately or consciously sponsor teaching as a mode of continuing education. However, it is recognized by top management as serving the following purposes:

1. It reflects favorably on quality of the laboratory staff members when they are accepted to teach at nearby universities.

2. It contributes to the knowledge which the university faculty have about the laboratory and the quality of its personnel, creating a potential for cooperative relationships -- for example, in arranging dissertation work to be done in-lab rather than on campus by laboratory staff who are students.

Teaching In-Lab, Non-Credit Courses. Some of the part-time teachers among the R&D scientists and engineers interviewed comment on the level of learning and quality of student performance in the in-lab courses they have taught. Some are quite enthusiastic about the benefits derived by their students and others quite disappointed. While this range is to be expected, it does raise the question of standards in non-credit courses, which we have discussed in Chapter V in relation to non-credit course work.

Another question raised by teaching as a mode of continuing education is the extent to which management is exploiting the potential for teaching by their own staff to their own staff. It appears that there is much greater potential for this than is now being realized. However, having laboratory staff teach in-lab (or on a campus) does pose questions for management about the use of R&D professional time. As one top manager commented:

> We have this internal sort of college refresher training for engineers. It's a six-weeks' refresher course where the guy is relieved of all responsibilities. We (in R&D) put together a faculty -- about half of it from my organization. It's beneficial to my guys because they enjoy putting together lectures. For the students it's probably worth it.... But I doubt it affects the work they do in a major way. The personnel organization would want to do this at a level that could interfere with my research activity, but that's their business....I have fully cooperated with the personnel people in providing staff for their program. If it were expanded much more, we would have to face up to whether we want to pay people to teach rather than do research. Our people are hired as researchers. So far it's just been a diversion from their research.
>
> Ph.D., Physics, age 40, Top Manager

Summary and Conclusions

This chapter completes the findings on the nine modes of continuing education identified by the R&D scientists and engineers participating in the study. The data show the importance of reading and of the interaction modes to keeping up to date. The data of other chapters show that the course work modes are most important for learning the fundamentals of a subject, as well as for refresher and updating purposes.

In spite of the fact that there is widespread feeling and belief that it is impossible to keep up with the volume of current scientific and technical literature because of lack of time, the average number of hours spent reading work-related literature is about ten per week, with an additional nine spent in reading non-work-related literature. And in spite of the fact that research people need familiarity with a broad base of current knowledge, they inevitably narrow the scope of their reading to bring it to bear on the job as well as to utilize whatever short-cuts to the literature are available through their libraries and other sources. The library is an important adjunct to the reading of R&D professionals. Its special role in furthering and supporting continuing education efforts needs to be studied in other research.

We recommend that laboratory managements continue to seek ways of assisting scientists and engineers to cope with the information explosion in the literature. Among the ways found in various laboratories in this study are the following, all of which are considered by the laboratories using them to be of value:

1. Small libraries specialized in the work of a department or subunit within the laboratory, located in the work place, and cataloged and serviced by the central library.

2. Journal subscriptions for departments or subunits which can be shared by a small number of people, rather than the circulation of journals throughout the laboratory as is now done in some organizations.

3. Book-refund policies which share the cost of books and journal subscriptions with the individual. One laboratory pays half the cost of any scientific or technical book purchased by a researcher. Almost every scientist interviewed in this laboratory mentioned this service as a help in keeping up to date.

4. Encouragement of scientists and engineers to establish journal clubs and informal grass roots seminars during lunch hours and after hours for the purpose of reviewing and discussing literature pertinent to work. (Supervisors and managers also should participate in these clubs to demonstrate their interest and encouragement.)

5. Providing opportunities to teach in-lab courses for the benefit of other scientists and engineers in the work force.

We recommend to professional societies and other publishers of journals and magazines reporting the scientific and technical literature that they consider ways of increasing the number of review articles available to their readers. We suspect that there is much more emphasis placed on publication of original research findings than there is on the integration of these into coherent and comprehensive statements of emerging trends in theory and their implications over a broad range of topics. In our interviews, there is an expressed need to correct this imbalance.

CHAPTER VIII

CONTINUING EDUCATION AND THE WORK ENVIRONMENT

This chapter considers some influences in the work place itself. Out of the many nuances and subtleties which go into the working atmosphere, supervision and the kind of work (i.e., primarily research or primarily development) were selected as focal concerns for the study -- both these are occasionally mentioned in the literature as important influences on the individual's relation to continuing education.

First, supervision is viewed from two sides. The interviews with 54 supervisors discussed their own supervisory efforts and attitudes toward continuing education, how and to what extent they undertake to encourage individual scientists and engineers to participate in the various modes, and what they think and do about men whose own inner motivation is not sufficient to initiate continuing education efforts which the supervisor considers are needed. From the other side, the scientists and engineers themselves report on their supervisors, illuminating how the supervisory practices appear when one is on the receiving end of them.

The kind of work falls into two subgroups; 115 men who are primarily concerned with the research end of the R&D spectrum, and 59 who are predominantly engaged in developmental activities. Examining these two groups in their continuing education modes and activities points up some further implications for continuing education. This study only begins exploring these dimensions, and so the findings must be taken as suggestive rather than as definitive.

Supervisory Influence on Continuing Education

Chapter IV (Table IV-4) reports that eight percent of the questionnaire sample cited supervisory encouragement of continuing education in response to a direct question about what else was needed in their laboratories. A closer scrutiny of this area can reasonably begin with studying the interviews with the 54 supervisors. What supervisors do depends on how they conceptualize their role in general as well as in relation to continuing education activities among their men and on the degree to which their own enthusiasm or negativism for continuing education is imparted, actively and consciously as well as indirectly and perhaps even unwittingly. To obtain an understanding of these attitudes and actions, the interview sample was designed to include supervisors who were asked a series of questions about their efforts to encourage or discourage continuing education for subordinates.[1]

On the basis of the 54 interviews, three types of supervisory approach can be distinguished: the 54 men are about equally divided among the three categories.

The "Administrator" type typically does what he can to motivate his subordinates to avail themselves of any employer-sponsored opportunities in continuing education which he regards positively. He conceives of his job as implementing stated laboratory policies, as encouraging subordinates to use the existing resources; and he is proud of the numbers of subordinates who pursue various modes of employer-sponsored continuing education. The following are representative quotations from "Administrators":

> We encourage continuing education very much. The opportunities at the Lab are fairly substantial. The general attitude here is to encourage the use of opportunities that are available. I think in my division we are one of the heaviest users of the training facilities in the Lab. This includes the approval and subsidization of course work at local universities, and allowing people to take government-sponsored courses locally. There is a sabbatical program in which we are more than represented proportionately.
>
> Master's, Physics, age 46, Supervisor

> My only route is to encourage them to come to me with specific classes they want to take because I have no way of generating or setting up things. I can fight for them one at a time, which I do. I have a man at Dayton. I

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[1] For the purposes of this study, a supervisor is defined as being either immediately above personnel who are actively engaged in scientific or engineering work or else one step higher. In government, these first and second levels correspond to section and branch chiefs respectively in most laboratories. Similar titles are not consistently used in industry. However, directors of major units within the central research laboratory correspond to the definition of second level and the supervisors immediately below them correspond roughly to the first level. In both government and industry, because of the shallowness of these organizations, the second level is just under the top management, or is a part of the top management, of the laboratory, depending on its size.

> personally selected him to go there. He is a very capable man. I discussed it with him when I was selecting him, and he thought it was a good idea. Another man is going to school this fall for celestial guidance training. He said he would be interested in this. I have about ten or 12 people whom I have tried to get into the courses that the lab has arranged for or is actually teaching.
>
> Bachelor's, Engineering, age 39, Supervisor

The Administrators are actively interested in the problems of their subordinates, and will try to arouse their interest in undertaking specific activities. At the same time, as the second man says, the Administrator is likely to regard this area as equivalent to many others where he implements policy in a constructive way. As a result, his activity is also rather impersonal and more a matter of accepting the needs of personnel than of "generating or setting up things."

The "Innovator" type of supervisor interprets his role in such a manner as to create new opportunities in addition to the existing ones, to provide novel and interesting ways for subordinates to undertake continuing education. The Innovator is himself a stimulating, motivating element in the working environment. He is considerably more sensitive than the Administrator to the needs of his people, and is keenly perceptive of the resources available in the wider community, both those which do and those which do not fit these needs. His enthusiasm for continuing education is such that he will contrive and create both stimulation and such resources as specific workshops, or courses, or special seminars. He sees these techniques as ways to keep his staff at the frontiers of knowledge by incorporating the latest knowledge available into easily digestible and accessible forms. The following quotations illustrate the typical Innovator approach:

> I hired a chemist to do a job in a developmental area. I introduced him to two different projects which cut across different areas -- across the breadth of problems. He realized he was deficient in some areas. I motivated him to take different courses. He then helped set up a training program to help other people at the technicians' level to make this transition to broader problems.
>
> Master's, Chemical Engineering, age 33, Supervisor

> Because there is so much literature available, I have tried to take each junior person and give him an area to become an expert in. What I have done is given him a list of areas and ask him to select the area he would like to learn about -- something where it would be nice if we had a

> specialist in that field. So I have built up a few people who are specialists. Whenever we get a job requiring that specialty, we have him work on it. This works very effectively with the junior people.
>
> Master's, Mechanical Engineering, age 30, Supervisor

> The other thing is I try to upgrade and advance their type of research, pushing them into the next logical step. Maybe I pull a few articles together and put them into a binder and say, "This is where my study has gotten me, and I would like to have you decide whether this is the next experiment we should be doing or not." I push them that way.
>
> Ph.D., Nuclear Physics, age 52, Supervisor

It is clear in these quotations that the Innovator type of supervisor is vividly aware of the potency of new knowledge and of continuing education, and regards these activities as central to his supervision of the others.

The "Inactive" type of supervisor is basically passive and noncommittal in his attitudes. Because he conceives of self-development (and continuing education) as a responsibility of the employee apart from the working environment, he neither stimulates subordinates to pursue additional knowledge nor initiates continuing education activities on their behalf. He is aware of, and deplores, the lack of motivation shown by particular individuals, but he undertakes positive action only if the employee takes the initiative and the activity is within the framework of existing policy. He will make "pious" statements about the desirability of continuing education, but in fact he subscribes to a rather fatalistic and resigned view of people and, indeed, of leadership. This quotation is typical of the Inactive managers:

> Sometimes people want to take special courses, and I always approve, although I don't go around too often and say, "Why don't you take more courses?" We have a review of each person that is not related to salary adjustments, but just to the full consideration of the position, performance, and possibilities for improvement. In those areas I try to point out the direction in which the technology is moving and how we all have to be alert to increasing and expanding our areas of understanding. There is a lot of things I don't do. I don't organize symposia or things like that very much. I haven't found them useful, to be honest. My view is that almost all education is self-education, even when you are going to a formal institution. One of the requirements for the person in research is that he is motivated and possesses the tools for self-education.
>
> Bachelor's, Physical Sciences, age 44, Supervisor

It is clear that these three kinds of supervisor will not only actually do and say different things about continuing education among their subordinates, but will also play different roles in the motivation which their men feel toward continuing education. That is, the three types will not be "equivalent" in arousing in subordinates the curiosity, enthusiasm, and energy needed to tolerate the inconveniences and the efforts demanded by substantial involvement in continuing education.

These three supervisory types represent different levels in the quality of supervision as far as continuing education is concerned. The Innovator is clearly the one most likely to stimulate and motivate subordinates to self-development. The Administrator, despite his conscientious implementation of policy and despite his pride in having subordinates who use the available resources, is considerably less likely to encourage important additional study, efforts, and purposefulness in his staff.

It is almost a truism in research management that engineers and scientists should be shifted around from time to time and given assignments that stretch their knowledge thin. This is particularly important for younger people, to broaden their backgrounds and capabilities early in life; the Innovators implement such activities. Supervisors in general should apply this same logic to their efforts to get subordinates involved in new ideas, theories, concepts, and tools relevant to their work or their potential work.

Laboratory managements would be well advised to encourage and help supervisors to adopt the "Innovator" approach in dealing with subordinates regarding continuing education. Making supervision aware of the differences between the "Innovator," the "Administrator," and the "Inactive" types may make considerable difference to supervisors in conceptualizing their roles and responsibilities in influencing subordinates to continuing education.

In the section immediately following, the attitudes the 54 supervisors expressed toward the "unmotivated" men in their R&D labs are examined. The material so far has already provided one important tool for understanding the implications of what they say: that is, systematic examination inevitably reveals that motivation is not a constant element inside a single person; it emerges as a dimension of the interactions of persons with each other and with the environment they share -- including, very importantly, the meanings, activities, goals, and needs embedded in that shared environment as well as all those brought to the situation by the participating persons.

Dealing with Unmotivated Men

A related but different set of questions was asked of these same 54 supervisors, having to do with how they handle subordinates who may be unconcerned about, or lack motivation for, keeping themselves up to date. As reported in Chapter III, top laboratory managements have no formulated policies or firmly established practices for dealing with such "unmotivated" people. This is left to lower levels of management and to the supervisors, who cope with the problem as best they can. This section presents the views and reported actions of the interviewed supervisors.

An important point is that the unmotivated men are, of course, spontaneously defined by the supervisors in the interviews. No count was kept, but each supervisor easily recognized at least one or two in any small group of ten to 20 men. The supervisor defines these men subjectively, vis-a-vis his own standards and experiences with men he considers highly or adequately motivated. The material so far in this chapter shows clearly that different supervisors use differing judgments here: what an Innovator supervisor might consider a man who needs special stimulation and interest, an Inactive supervisor might regard as quite normal and adequate in his striving for continuing education. A second important point is that the supervisor's own behavior will already have played a part in the man's apparent motivation. A supervisor who considers it pointless to try to get men interested in new knowledge will probably have a different kind of audience than one who habitually talks, plans, and undertakes activities precisely designed to show his subordinates the excitement and benefits of new knowledge.

Supervisors most frequently mention two types of employee who are unmotivated toward continuing education:

1. The older professional who has narrowed his specialty over the years and whose work has prevented his contact with broadened horizons or his keeping abreast with the more general advances in his field.

2. The person who prefers doing what he knows best and is afraid or unwilling to branch out into other fields which would require expanding his knowledge.

For both types of man, management has erred in allowing them to persist in their behavior patterns for so long that they are comfortable doing only what is familiar and consequently resist efforts to get them into new lines of work. Supervisors characterize these individuals as having reached their peaks; their salary potentials are at their heights; nothing in their positions will change markedly -- and consequently, they have given up.

> There is that group that feels that no matter what they do they won't get anywhere. I have two senior people like that. They feel their salaries have peaked out. They feel it's too late for them. They're old in their attitude, not in years. They feel that nothing is going to change in their position, and they're right. Because of their attitude, nothing *is* going to change.
>
> Master's, Mechanical Engineering, age 30, Supervisor

Psychologists would agree with the supervisor's assumption that the man's inner conceptions, goals, and wants are extremely important to his motivation. At the same time, among the three types of supervisor, only the Innovator is prone to bring the potentialities of continuing education, of new knowledge, of new professional experience directly to the work of the individual scientist or engineer. He regards continuing education less as an instrument for substantial changes in field or level or income than as a means for having livelier and more rewarding experiences in the normal pursuit of a professional career.

Supervisors faced with the problem of an unmotivated individual report dealing with him in one or more of these ways:

Changing the Environment. Some supervisors try to manipulate or influence the environment which surrounds the person who appears to be in need of some form of help. These supervisors often attempt to introduce new and diverse work situations which will force this person to cope with problems he has not met before. The manager may deliberately introduce stress in the individual by changing his work assignment to a new but related area, or he may change the person's project altogether. These tactics are aimed at impersonally enforcing some form of continuing education which will cope with the new problems to be faced.

The supervisor may try to inject new and challenging ideas and induce stimulation by bringing in other colleagues to work with the unmotivated, or assigning him to work with some younger, more recently graduated, professionals who will expose him to new ideas as well as to a more competitive atmosphere.

Whatever method the supervisor chooses, his ultimate aim is to initiate a process whereby the unmotivated professional will be faced with a new and challenging situation, thereby shaking off lethargy and disinterest, as shown in the following:

> You can't deal very well with such people in our type of organization -- the guy who doesn't want to. Your output isn't as tangible as it might be. You have no goals you can set a guy to very easily. The problem is to make him interested. And usually this can be done, either by a change of project within his own specialty or by a more substantial change, or shaking up in the way of assignment -- by assignment within a different group so that he is interacting with other people and in an allied but somewhat different discipline.
> Master's, Physics, age 46, Supervisor

Pressuring the Individual. Two methods of pressuring the individual are used by supervisors. One is to directly threaten him with removal; the other is indirect; the supervisor attempts to persuade the individual by stressing potential material rewards, job related prestige, and professional status appeals, thus pointing out that his performance should be upgraded.

> I talk about continuing education straightforwardly with these people. I tell them the directions the company is going in and make it alive and clear how what we are doing ties in with this company. This is a good motivating force. I don't push; I explain alternatives. I will point out deficiencies and limitations. If he accepts these, he is going to accept a job of less demand. It's not hidden from them that pay ties in with results.
> Bachelor's, Chemical Engineering, age 32, Supervisor

No Longer Trying to Motivate. The third approach to solving the problems of the unmotivated is to remove them to another work group or lab out of the supervisor's jurisdiction, or to make the employee so uncomfortable that he leaves of his own accord, or to transfer him to another job that downgrades him from his present position but is more suited to what the supervisor thinks will fit his potential.

> By the time you reach 40 you are either going up or you are going down. They are either at the bottom of the list, or they have been learning all along. Ten percent are in the bottom group, but I have kind of pushed them out. They don't get raises for a few years. Also, any large outfit has some low-caliber jobs, and we put them on that.
> Master's, Aeronautical Engineering, age 53, Supervisor

> When you discover people like this, assign them jobs they don't like and get rid of them. I have very little patience with them.
> Bachelor's, Physics, age 30, Supervisor

The first two of these approaches -- changing the environment and putting on pressure -- are characteristic of the "innovator" and "administrator" types of supervisor. The third -- shunting them off, etc. -- is less frequently found among any of the three supervisory types -- probably because the opportunities for getting rid of people are somewhat limited.

As the various quotations indicate, "unmotivated" comes in several guises. Some limitations are intrinsic to the person -- the boundaries of his talents and capacities, for example, or actual energy resources, or, much less predictably and consistently, age and level of lifelong aspirations. Each of these qualities exhibits itself influenced by the context of the surrounding environment. The extent to which poor or faulty supervision embellishes "unmotivation" is a question which this study can only raise as an issue, and cannot answer -- but it is discussed after presenting the subordinates' side of the supervisory picture. Here, however, there is cause for concern in the very fact that supervisors recognize some of their people as unmotivated. Many of the recommendations in the literature assume that if employers, schools, and professional societies will only do their part in creating opportunities for continuing education, then individuals will be motivated to take advantage of them. Once again it is necessary to point out that this does not necessarily follow. As one supervisor put it:

> I had one man, he wasn't doing an unsatisfactory job, but he wasn't progressing. I can't say it's impossible to motivate these kinds of people, but if their sense of values doesn't dictate a need to progress on the job, then what can you do to them? (What should management's attitude be?) I honestly don't know. People of that sort have a place. We have a need for these people. They can find a home, but they limit their earning power. (So if they accept that and their work is satisfactory, what would you say?) They are contributing to the organization, and they can work here.
> Master's, Industrial Engineering, age 45, Supervisor

Given the needs of their laboratories, management and supervision must take active steps to prevent professionals from slipping into the kinds of ruts that permit falling behind, overspecialization, and unwillingness to diversify and develop new interests and capabilities. The various personnel and training techniques, modes of continuing education, and approaches taken by innovative and creative supervisors are probably adequate to this task. However, the over-all task of continuing education can only be accomplished if all the supervisors of research people are required and encouraged to be alert to these dangers and to seek to prevent them before they occur.

Subordinates' Views on Supervisory Influence

The scientists and engineers themselves present a different picture of the supervisor's influences in favor of continuing education. Tables VIII-1 and VIII-2 give some relevant statistics on this point. These can be compared with those of Dubin and Marlow, whose study of Pennsylvania engineers emerged with considerably less favorable attitudes:[2]

> Approximately one-third (34%) or 688 engineers believed that their immediate supervisors encouraged them to actively pursue further education or training. However, 64 percent, or 1,313 engineers, felt that their supervisors took a non-committal attitude, and 2 percent, or 38 engineers, believed that their supervisors actually discouraged them from taking educational or training courses.

A substantial portion of both scientists and engineers in this study report that their supervisors are noncommittal. The people who reported this were asked to give examples to illustrate the supervisor's attitudes and behaviors, and the usual explanation turns on the supervisor's concern with work production -- i.e., with the economic value of the employee's time. The supervisor does not want to lose the productive time of his people while they are off the job in some continuing education activity. For example:

> I have circled "noncommittal" although "discourages me" might be a better choice. Despite his obvious distaste for losing my productive capacity to attend courses, I have been able to go.
> Ph.D., Physics, age 31

Aside from the somewhat higher frequency of this kind of statement by engineers, there are no outstanding subgroups -- they do not cluster by age, degree

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[2] Samuel S. Dubin and H. LeRoy Marlow. Continuing Professional Education for Engineers in Pennsylvania (previously cited in Chapter I), p. 76.

TABLE VIII-1

SUBORDINATES' VIEW OF SUPERVISOR'S ATTITUDE TOWARD CONTINUING EDUCATION

RESPONSE	Scientists N=231	%	Engineers N=163	%
Stimulates and Assists Me in Keeping Myself up to Date	141	61	80	49
Takes a Noncommittal Attitude toward Continuing Education	79	34	72	44
Discourages Interest or Participation in Continuing Education	5	2	8	5
No Answer	6	3	3	2
TOTAL	231	100	163	100

TABLE VIII-2

SUBORDINATES' VIEW OF EFFECT OF EMPLOYER POLICY ON OWN MOTIVATION

RESPONSE	Scientists N=231	%	Engineers N=163	%
Strongly Encouraged Me	84	36	40	25
Partially Influenced Me	91	39	61	37
Had No Effect	52	23	58	36
No Answer	4	2	4	2
TOTAL	231	100	163	100

held, salary, or government vs. industry laboratories.

In general, employer policy on continuing education has motivated fewer people than has the more direct stimulation of supervisors. This is seen in Table VIII-2, and Dubin and Marlow reported similar findings in their study. It seems likely that, in many cases, the employer's policy is a permission rather than an encouragement. When asked to comment, the men who chose "partially influenced" as their assessment of employer policy say they perceive the focused encouragement, the instigation, as lying elsewhere -- most often, in the actualities of work or within themselves.

> The specific area and job assignment determine whether I learn a new field and thus continue my education, informal though it may be.
> Bachelor's, Electrical Engineering, age 34

> Actually, conditions of work -- pushing the state of the art further -- rather than company policy is largely responsible for stimulation to continuing education.
> Master's, Physics, age not given

The men who cite employer policy as positive -- whether strongly or partially -- cite specific assistances they have received, such as tuition refunds, opportunities to attend short courses and meetings, the chance to pursue reading on the job, etc. In short, they perceive employer policy as having benefits for them, but benefits that are not explicit goads so much as they are instruments for facilitating the man's study and learning goals.

There should be particular concern about the 23 percent of scientists and the 36 percent of engineers who say that the organization policy has had no effect on their continuing education. These scientists and engineers work in all the laboratories studied, but concentrate -- understandably -- in industry #9, the one which has the fewest components in its employer program. The correlations indicate that, wherever they are, these men are the same ones who say their immediate supervisor takes a noncommittal attitude or actively discourages them from continuing education. The influence of the supervisor (in contrast, or in addition, to employer policy) is very clear in the statements made by these people, as in the following typical quotation:

> The laboratory in general, within the last few years at least, will pay tuition and give time off for continuing education. This is the official laboratory policy, but again as the policy is implemented at the lower working levels, sometimes it leaves much to be desired.
> Ph.D., Physics, age 31

Formulating an overview of how scientists and engineers regard supervisor and employer policy on continuing education highlights again the very personal nature of motivation. Employer policy, unless it is implemented in an active and energetic way -- comparable to the approach of Innovator supervisors -- will probably be regarded as somewhat ancillary to the man's desire (or disinclination) for continuing education. He can see it positively when it facilitates his efforts: but a substantial number of men are exposed to an attitude on the part of "higher-ups" which focuses on their economic value in ongoing work and which clearly sees continuing education activities as all too readily infringing on the employer's prerogative of demanding time and energy for production.

None of our data directly assess the over-all atmospheres of the labs, and yet it becomes clear that there are conspicuous differences. The Innovator supervisors generally present a picture of men who strive to make knowledge, an awareness of frontiers, and a concern with the changes in the frontiers part of the normal and usual thinking and talking in their groups. The Administrator types hint at work groups which are more self-contained and down to earth, working vigorously at the projects currently assigned and underway, and providing enough permissiveness so that a man who becomes curious about something broader can be free to broach the topic. The Administrator wants his people to have both feet in the work situation, and he will encourage them to keep up by using the activities or modes sponsored by the employer. Surely this represents a very different work atmosphere in so far as continuing education is concerned. Finally, the men suggest that "noncommittal" attitudes and Inactive supervisors often go along with work atmospheres where there is little energy lost from the immediate tasks. The interview comments suggest that, in fact, there will probably be an understandable even if not explicit discouragement of activities or interests which detract from productive work time.

Further, the scientists are less liable to such dampening than are engineers. This finding is compatible with the broad outlines of their training and with the habits they are likely to bring with them on the average (there are exceptions in both directions in this sample). The scientists are likely to have had more years in intellectual training, and training that is probably considerably more theoretical than that of the engineers, who are more likely to have had undergraduate training that heavily emphasizes skills. Without being concerned with the chicken and the egg, we can comprehend the fact that the supervisors of engineers are less often encouraging, and less often highly encouraging about continuing education than the supervisors of scientists. It is also likely that the engineers themselves entertain fewer concerns for continuing education. The next section discusses the influence exerted on continuing education activities by type of work.

Use and Importance of Modes by Type of Work

One objective of this study is to determine what differences, if any, exist in continuing education needs between scientists and engineers. Putting all the scientists into one group and the engineers into another, there are few differences distinguishing one from the other either in the modes used or in the importance attached to them. There are engineers engaged in research who, for all practical purposes, are indistinguishable from scientists in their continuing education needs. However, another way of examining this issue does reveal some differences of consequence for planning and programming for continuing education needs.

R&D laboratories can be thought of as covering a range of activities from heavy involvement in research, defined as "basic or applied," to heavy involvement in development, defined as "design or translating knowledge into useful form." Using these definitions on the questionnaire, each person indicated on a scale from zero to "90+%" how much time he spent in research and how much in development work. The extremes of the research to development continuum can be located by adopting 70 percent or more time in research, or 70 percent or more time in development, as a criterion of heavy involvement. Table VIII-3 shows the composition of these extremes [illegible] our questionnaire sample. The research group, as expected, is composed primarily of scientists with advanced degrees. To the extent that it includes engineers, these are mainly men with advanced degrees. The development group is composed primarily of engineers with masters' and bachelors'. There are more of the heavily-research-involved people in government than in industry, and more of the heavily-development-involved people in industry than in government.

TABLE VIII-3

CHARACTERISTICS OF THOSE SPENDING 70 PERCENT OR MORE TIME IN RESEARCH OR DEVELOPMENT

CHARACTERISTICS	Heavily Research Involved		Heavily Development Involved	
	N	%	N	%
Scientists	97	85	12	20
Engineers	18	15	47	80
Ph. D. s	62	54	7	12
Masters'	27	23	19	32
Bachelors'	25	22	29	49
No Information*	1	1	4	7
Government	68	59	20	34
Industry	47	41	39	66
TOTAL	115	100	59	100

*Degree information omitted on the questionnaire.

Keeping this definition of the extremes in mind, the more important information for this analysis is presented in Tables VIII-4 and VIII-5, which show the degree of association between amount of time spent in research or development with other measures obtained in the questionnaire.

In general, the scientists and engineers at the research extreme of the spectrum use a greater number of different modes than do the people at the development extreme. Tables VIII-4 and VIII-5 show that there is a direct and significant relationship between heavy research involvement and engaging in reading and the interaction modes of continuing education -- attending workshops on specific subjects, in-lab lectures, and professional society meetings. This relationship is not characteristic of the heavily-development-involved people. In fact, the negative correlations between heavy development and involvement and attending in-lab lectures and professional society meetings indicate that development people either avoid these modes or do not have them available.

TABLE VIII-4

CORRELATIONS* BETWEEN TIME SPENT IN RESEARCH OR DEVELOPMENT WORK AND USE OF EDUCATIONAL ACTIVITIES

EDUCATIONAL ACTIVITY	Research r=	Development r=
Workshops on Specific Topics	.14	(-.04)
In-Lab Lectures and Seminars	.34	-.18
Expenses Paid to One Professional Meeting Annually	.29	-.23
Time Off to Attend Professional Meetings	.15	(-.09)
Total Number of Different Activities Reported as Used	.28	-.15

*These correlations are based on all 394 men in nine laboratories who answered the questionnaire, and indicate the degree of association between the measures across the entire range of research-to-development. Had only the extremes of one or the other involvement been used, the correlations would be higher, but the direction (plus or minus) would be unchanged.

Correlations in parentheses ( ) are not significantly different from zero. Correlations of .10 are significant at the p=.05 level.

Development people tend to rank the course work rather than the interaction modes of continuing education as important in keeping themselves up to date, as shown in Table VIII-5. This applies to both university credit courses and to in-lab, non-credit courses.

TABLE VIII-5

CORRELATIONS BETWEEN RANKING "HIGH" ONE OF THE EDUCATIONAL ACTIVITIES AND PERCENT OF TIME SPENT IN RESEARCH OR DEVELOPMENT WORK

RANKING "HIGH" IN IMPORTANCE IN KEEPING SELF UP TO DATE:	Research r=	Development r=
Reading the Scientific and Technical Literature (Journals, Books, Abstracts, etc.)	.11	(-.01)
Receiving Tuition Refund for Courses Taken	(-.07)	.10
In-Lab Formal Courses on Scientific or Technical Subjects	(-.06)	.11
Attending In-Lab Lectures, Seminars, Conferences	.20	-.10
Attending Professional Society Meetings	.27	-.22

See footnote to Table VIII-4, which also applies here.

These findings are a further indication that laboratory managements, professional societies, and universities and colleges should have available a wide selection of continuing education activities in order to provide sufficient alternatives to people in research and development. Another implication of this finding is that as the proportion of engineers trained at the Ph.D. level and engaged in research increases,[3] the more likely it is that the difference between scientists and engineers in R&D with respect to continuing education activities will tend to disappear.

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[3] Interim Report of the "Goals" Committee (previously cited in Chapter I) states that since the turn of the century the number of Ph.D.s in engineering is growing twice as fast as the national average for all Ph.D. degrees granted (p. 17); in addition, the Committee also states that approximately one-third of all engineering Ph.D.s are in teaching, one-third in research, and one-third in all other functions combined (p. 37). However, among graduates receiving the Ph.D. in 1962-65, 90 percent took their first job in R&D (p. 38), suggesting that a pronounced shift in the distribution of engineering Ph.D.s is taking place.

Although there are differences between scientists and engineers in the research and development ends of the spectrum as to which modes are most used and regarded as most important, this is not reason enough to conclude that any one mode should be available to one set of professionals and not to the other. For the purpose of keeping people up to date, all the various modes of continuing education should be available to both scientists and engineers so that each individual can select what he needs. These results suggest which types of activity will be demanded in relation to the relative proportions of "research" to "development" personnel in R&D. The data suggest that development-oriented people are more likely to use, and regard as important, the course work modes. Consequently, managements with a high proportion of development-oriented personnel in R&D should make sure that these modes are available either in the community or in the laboratory. Additional recommendations are made in Chapter V as to the standards of learning which should be applied to in-lab courses. Managements with a high proportion of people at the research end of the spectrum will have to support the interaction modes more heavily than the course work modes. With specific reference to attending professional meetings, data presented in Chapter VII suggest that more of the junior-level personnel should be exposed to this type of information and stimulation.

Summary and Conclusions

As shown in the first section of this chapter, supervisors can be categorized into three types on the basis of how they deal with continuing education for subordinates. The Innovator is the most productive of stimulation to continuing education.

Most supervisors claim that they at least attempt to deal with unmotivated people by various devices involving changing the environment or pressuring the individual directly. But there is a point beyond which it does not seem worthwhile to most supervisors to do anything with these people so long as they perform a useful and needed job in the laboratory. To be sure, this may represent a "waste" of manpower if their potential truly goes beyond what they have achieved. However, it is doubtful that management and supervisory action can have much impact on those persons who are satisfied and content with the status quo to the point of resisting change.

On the basis of the scientists' and engineers' reports of supervisor and employer policies, supervision more often influences them in undertaking continuing education than does employer policy. Formal policy seems to be helpful primarily in two ways: it provides resources for, or facilitates, continuing education activities; it is stimulating, especially when it is combined with encouraging supervision. A substantial number of scientists and engineers, however, report indifference to, or active discouragement of, continuing education in their work situations, and they usually feel that it stems from a preoccupation with their being directly productive, though there are hints of other forces at work.

Some differences are reported in use and importance of various modes by type of work at the extremes of "research" and "development" within the R&D spectrum. These differences probably can be generalized beyond the 17 laboratories. The engineering literature on continuing education reflects a preoccupation with course work which is found primarily at the development end of the R&D spectrum. In our sample, there are more engineers at this end of the spectrum than scientists, and this distribution is probably usual.

We recommend that top laboratory managements make explicit that one of the functions of supervision in R&D is stimulating subordinates to continuing education and reviewing with them (at least annually) their plans for self-development. Conscious recognition of what the "Innovator" type of supervisor is and does will help clarify what management can demand and expect of supervision.

CHAPTER IX

THE LABORATORY-UNIVERSITY INTERFACE

Universities and colleges occupy a central place in continuing education, primarily because they are specialists in education and set the standards of quality for student performance in learning. The primary function of academic institutions is that of "nurturing a scholarly atmosphere and granting of academic degrees at various levels."[1] There is little demand for radical changes in the academic programs leading to degrees, although, to be sure, recommendations for improvements are made, and there are expectations of continuous development and growth in education.[2] On the other hand, the continuing education literature is replete with references to what specific universities and colleges are doing and also to what, in general, academic institutions should be doing in continuing education. Chapter I reviewed some relevant literature on the university-employer interface and listed the major issues which will be developed in more detail in this chapter.

The purpose in visiting the universities and colleges located near the 17 participating laboratories was to provide more of the context within which employer-sponsored programming and planning are done and within which the scientists and engineers undertake continuing education. We sought to obtain academic points of view on continuing education, information on specific continuing education activities (or the reason for their absence), and understanding of the relationship between the laboratory and the school.

In all, 71 academic persons were interviewed in 24 schools. In 18 schools, the interviews and information were obtained in campus visits and face-to-face interviews. In three schools, telephone interviews were held with one or more faculty members involved in continuing education. From three more, information was obtained by mail. In each of the 24 schools, we tried to contact the deans of engineering and department chairmen of chemistry, physics, and mathematics, as well as any other individual suggested to us as being knowledgeable about continuing education. Table IX-1 describes the positions held by the 71 academicians interviewed.

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[1] Joint Advisory Report (previously cited in Chapter I), p. 53.

[2] "Goals" Committee report (previously cited in Chapter I), p. 6, makes this statement; it is supported by our interviews with top laboratory management.

TABLE IX-1

POSITIONS HELD BY ACADEMIC PERSONNEL INTERVIEWED

POSITION	Number
Vice Presidents	3
Deans and Associate Deans	26
Department Chairmen	19
Heads of Extension, Evening, and Other Continuing Education Units	14
Directors of Centers for Continuing Education	4
Other Faculty	5
TOTAL	71

All but three of the 24 schools are universities granting both masters' and doctorate degrees in most, if not all, fields of science and engineering. Seventeen of the 24 are private, and the remainder are state-supported schools. All of these schools can be described as large; the smallest has over 2,000 students. The names of these schools are listed in Appendix B.

The Place of Continuing Education in Academic Activities

In general, the academic people interviewed stress the point that the school's primary functions are to provide training for students seeking degrees and to generate new knowledge through research. At the present time, these two functions have priority over continuing education. This does not mean that these academic people think continuing education is unimportant; it does mean that decisions about where and how resources are allotted are delegated to the individual faculties of engineering, chemistry, physics, etc.

Nineteen schools admit non-degree students to regular university credit courses.[3] That is, students may apply for admission to the school and enroll in any course they qualify to take without regard to meeting degree requirements. Chapter V reported that 15 percent of the scientists and engineers had enrolled in credit courses for continuing education purposes but were not seeking a degree.

Academic people generally agree that university credit courses are suitable for continuing education purposes only for those who meet any given prerequisites or can get by without meeting them, and who are also able to perform competitively with a heterogeneous student body of young degree-seeking students (see also Chapter V). Academic people also agree that credit courses should not be modified to meet the needs and objectives of continuing education. To do so would dilute the standards of the degree-seeking programs for which credit courses are primarily (or even solely) designed.

Admitting non-degree students to regular university credit courses is an important resource, but it typically requires little or nothing from the university. There is no adjustment of the course work, nor are special procedures devised for the non-degree student. It is thus "easy" to do in most circumstances. We regard this as a minimal level of continuing education activity for a university or college.

More interesting for continuing education is whether or not a university sponsors other modes -- short intensive courses, in-lab courses, seminars, symposia, and non-credit courses specifically conceived for scientists and engineers pursuing updating, refresher, or diversification objectives. By this criterion, 12 of the 24 schools can be classified as "active" and 12 as "inactive." Of the "active" schools, eight are private and four are state-supported;

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[3] Sixteen schools operate during evenings and/or weekends, so that employed students may seek degrees on a part-time basis in at least some of their science or engineering departments. This is advantageous primarily to those seeking masters' degrees. For the Ph. D. some schools permit part-time course work concurrent with employment and even fewer, in exceptional circumstances, permit dissertation work to be done off campus. However, they all discourage dissertation research off campus. These degree-seeking activities are desirable and worthwhile, but are not our province here.

of the "inactive" schools, nine are private and three are state-supported. Thus, the public/private dichotomy does not shift under this criterion.

Among the 12 "inactive" schools, the decision not to engage in continuing education programs has usually been made by the faculty jointly through discussion. The reason for the decision is to avoid diluting the main effort of teaching and research. For example:

> We do not offer any refresher courses because our philosophy is that our sister schools in this area perform this function, and we do not wish to dilute their efforts in this direction. Our experience has been that students who are primarily employees are not able to do the work in our courses because they lack prerequisites, especially in mathematics. We are aware of a demand to offer these people something they can do, but we choose not to meet it. Our emphasis is on teaching and research. We don't believe we can do other things. We don't believe in training students off campus. We are not interested in training students at that level.
>
> Dean, School of Engineering, Private University

Another dean of engineering put it another way:

> (Why is it that you and other schools like you don't do more to reach out into the community to meet continuing education needs?) That's like asking a company that started out with nothing and has grown to selling 20 million dollars of business a year: why aren't you out there selling 50 million a year? In 1950 we had 195 graduate students and in 1967 we have over 1,400. You're asking me: why don't you stop beating your wife? Private schools haven't made a decision not to engage in continuing education. It's just something they have not decided to do. We are doing what we can do. We have 140 faculty members. How many times 140 would we have to have if we were to go out and teach in every company that would want us to do it? You can't go to one and turn down others. Companies who want courses on their premises should hire teachers to give them. After all, the newspapers tell us we aren't turning out enough Ph.D.s to teach and by 1970 there will be a shortage and who is going to teach? And consider that we look for two or three years now to find a man we want to hire on our faculty. We recognize continuing education is a great problem and we are looking for solutions to it, but we can't do more than we are doing.
>
> Associate Dean, School of Engineering, Private University

Frustrations are also expressed by department chairmen in chemistry, physics, and mathematics. For example:

> If a company requested a refresher course for its people, our faculty would talk it over and decide if it would make a real contribution to this company's effort. For example, there is a need to acquaint research chemists in modern methods, NMR, and so on, and if the number of

> people to be taught was large, say ten or 12, we would probably do it. (Supposing there were a need to repeat it, would your faculty be willing to do this?) You have to remember that our faculty are businessmen in dealing with the government on contracts, they are teachers in dealing with the students, they are public relations men for the university, they are scholars in research. There are many things they must do that other colleagues in other institutions are not expected to do. We would try it once and if it really satisfied a need we would do it again. But there is a limit to what a university can do outside of its own main function, teaching and generating new knowledge through research. If a university does more than this, it corrodes what you are trying to do, which is to train students. The ACS puts on short courses on topical subjects. These should be used by someone wanting a course.
>
> Department Chairman, Chemistry, Private University

In these and similar quotations, several themes recur continually in the "inactive" schools:

1. In a community in which sister schools are already active in continuing education, a given school can "afford" not to make any competitive efforts.

2. Employed scientists and engineers are considered somehow different in academic caliber or quality compared to full-time degree-seeking students. Therefore, they require special courses and special handling which in turn requires additional (and unwanted) efforts on the part of the faculty.

3. Faculty (and space) resources are limited; they must be devoted first to teaching "regular" students and second to research. The "inactive" schools have no additional resources to put into continuing education.

4. There is a belief that employers should do more for themselves, and utilize resources besides the university for continuing education purposes; an example frequently given by academicians is that employers should sponsor and teach courses by and for their own staff without expecting universities to do this as an off-campus activity.

With reference to the first point above, it is true that certain of the "inactive" schools are located in communities where sister schools are offering considerable continuing education activities. For example, in the Boston area it is easy to find both "active" and "inactive" schools. In the Boston metropolitan area, the academic people interviewed in "inactive" schools all credit the "active" ones with fulfilling the functions of, and meeting the needs for, continuing education activities. The reader may interpret this for himself; we believe it is unreasonable to expect every school in an urban community to be equally active in, and committed to, continuing education. Similar examples are found in the metropolitan areas of New York City, Washington, D.C., and both southern and northern California. In some other urbanized areas, such as Houston, upper central Michigan, upstate New York, and the like, which have many fewer major universities, it is important that the schools that are located there be active in sponsoring and developing continuing education activities.

A possible topic of future research might be the distribution of university-sponsored continuing education activities along a continuum composed of several variables: size of community, number of schools "active" and "inactive," budget and endowment size, and the like, which could be correlated with various demographic figures on the population of scientists and engineers, number enrolled in continuing education modes at local schools and schools outside the geographic area, and so on. This would provide an index of university activity which could be correlated with potential or existing needs determined independently.

The 12 schools classified as "active" reveal an entirely different attitude, even though there is equal awareness of the problems and issues raised above. For example:

> We have done an inventory on what this university has done. This is the task of a committee on non-degree programs. It was instituted at the request of the alumni association, which has a committee on continuing education. One of our longest-term programs is the summer program in which we offer 35 to 40 short courses every summer. It was original when it started. Today it is much copied... One interesting fact is that of the people who come to these short courses, only 11 percent are alumni. At the other extreme, we have an intensive one-year mid-career experience for selected top-notch people... Something more needs to be done to put new options and new rewards into continuing education. Therefore, I feel that the content and form needs to be diversified. The kind of experience you get in sabbaticals and in other forms of continuing education is absolutely necessary. One might borrow a metaphor. "Democracy is a very inefficient form of government except for all other forms of government." Universities are a very inefficient form of education except for all other forms of education. Young people come in and have a variety of choice... We need to design continuing education so these people are active participants not passive customers. They provide their own structure to what we teach. We need to offer alternative components which they select from.
>
> Professor, Electrical Engineering, Private University

Another department chairman recounted the following history:

> The real difficulty in continuing education is mathematics... We did offer courses after hours to people employed in nearby laboratories. There were two serious difficulties, [the students and faculty were too tired after a day's work to perform well in the course]. So in a year or so I called together all the education directors in these laboratories and recommended that they give one day a week off to the people they wanted to send to us for mathematics. These men would spend all day here taking courses and talking with faculty and students and living in an atmosphere in which mathematics is going on. They fell in with this. It has not been a roaring success from our point of view, but it is better than evening courses. It is too soon to judge the outcome of this program yet. Much more effective is having our graduate students take summer jobs in these laboratories for the purpose of teaching and consulting with laboratory staff.
>
> Department Chairman, Mathematics, State University

The man just quoted has extensive experience both as a government-employed R&D mathematician and as a faculty member and department chairman. In his view, "more effective" means that employed scientists being taught by graduate students on laboratory premises learn more, and derive more job-related benefit, from such an experience than they do from taking courses in mathematics departments evenings, weekends, and generally on their own time. His view would be supported by some other academic people representing other disciplines who were interviewed.

Mathematics has a special importance for continuing education at the present time, because so many studies report that scientists and engineers need updating and refreshing in mathematical subjects. Consequently, as an aside we would like to comment further on this man's views. Mathematics is considered by this department chairman, as well as by many other mathematicians interviewed for this study, to be a demanding and difficult subject, requiring an individual's full attention for significant periods of time. It is not a subject which can be effectively learned after work through intermittent course work. Whether mathematics does, indeed, require such "total immersion" is an issue with which this study does not deal. What is important for our purposes is that this same chairman said that his motivation for sponsoring continuing education courses in mathematics was his felt obligation to provide the mathematical tools to people who need them, even though they could be expected to use them only inefficiently. As he put it: "I need certain tools also which I cannot handle with great skill, but I can at least use them."

To those in the field of continuing education, these attitudes are refreshing because they reflect an understanding of the problems, sympathy for the individuals involved, and innovation in seeking solutions. In the "active" schools, continuing education is still secondary to teaching and research, but it has a respectable second place.

The Shift from Credit to Non-Credit in Continuing Education

Both "active" and "inactive" schools report a rather impressive amount of negative experience with offering course work for credit on employer premises. One dean summarized four major efforts by his school to provide in-house instruction in credit courses, and concluded:

> We have had programs in the past ten years with the government and with industry, with various employers. The experience has led us to abandon them. (Why?) Number one, the caliber and quantity of students who wanted to participate and the response of these students to instruction. [Cites a high drop-out rate, poor attendance, and lack of interest of the employees.] We have had comparable programs here on the campus with uniformly good experience... We operate short courses, three days to two weeks. Our experience has been good with these. We attract as many students as we can handle, 30 to 50. We draw instructors from all over, and students from all over the country. So we have good experience with these and poor experience with local employers. There is not a good definition of what people want, that is one problem.
>
> Dean, School of Engineering, Private University

This man is reflecting a commonly found experience with off-campus teaching of credit courses among the universities visited for this study.

Why, if essentially the same types of person are involved, do off-campus courses "fail" and on-campus courses "succeed" in the same for-credit courses? Two points are made by this dean as well as others who were interviewed. One is that the students are not essentially the same. Management tends to be less than selective about who is admitted to in-lab courses taught by university faculty. As one dean put it: "All kinds of people show up who have no business being there, including the boss's second cousin." This obviously can be controlled by management and is controlled in the laboratories of this study in which there are university-taught for-credit courses. But obviously academic experience on the whole is negative.

The other point is more subtle. The academic people interviewed, by and large, believe that faculty members who teach credit courses off campus inevitably change their standards of student performance so that what is taught is intrinsically different from what is supposed to be taught in the course in order to obtain credit for it in the university. This point is delicate, because the implicit assumption behind it is that the "change" in standards is inevitably a lowering of standards. We do not wish to enter into this controversy here because we collected no facts on this point. But it does seem reasonable to point out that there is no existing research known to us on whether or not this assumption is generally valid, or on the circumstances in which it might be valid or invalid.

In addition, another point is repeatedly made by deans and department chairmen. They report having offered credit courses at the request of employers for which few or no students enrolled. This leads academicians to say that employers have not adequately defined their needs -- "what the market is" as one of the deans put it. Probably this is true, but part of the problem is the common, rather simplistic, assumption behind this failure that motivation to continuing education exists in the individual independently of his personality, prior training, and present work environment. This assumption has led some writers in the field of continuing education to assume that if opportunities are provided by universities, employers, and others, then scientists and engineers will utilize them. The experience cited by academicians and data given at other points in this report indicate that this is not so.

Regardless of the underlying causes, these kinds of experience have created an unwillingness among academicians to engage in teaching credit courses off campus and to concentrate continuing education efforts in non-credit, on-campus activities. (As reported to us, there are some courses, both credit and non-credit, being taught off campus by university faculty, but the number seems to be small and declining rather than increasing among the universities visited.)

It is fairly typical for academic people who were interviewed and who have experience with non-credit, on-campus activities in continuing education to report favorably on their experience. This is especially true of short intensive courses which are the most popular format used in the universities visited. But it is quite obvious that different standards are being applied to these non-credit activities than to credit courses. The latter must always be identical with those taken by degree-seeking students -- otherwise the credit loses its meaning for a degree. Non-credit courses, on the other hand, do not typically demand any specific level of student achievement: grades are not given, credit is not given, and whether or not the student learns only he himself can judge. "Success" seems to mean capacity enrollment, expressions of satisfaction from the students (and possibly also from their employers), and impressions of faculty that the non-credit course did, indeed, convey at least some learning to some of the students. This is quite a different matter from the rigor with which student performance in credit courses is judged.

We do not mean to imply that the same standards should be applied to both non-credit and credit course work. Rather, the issue of what standards should be applied to non-credit course work is a topic for further research, along with investigations of amount and quality of actual learning which does take place in the various modes of continuing education course work. On both these issues, there is little or no evidence of any kind in the existing continuing education literature. The importance of this lack of evidence will be immediately apparent whenever it becomes necessary to investigate the value and worth of new educational techniques such as tele-lecture, electro-writer, and other audio-visual media now being developed and considered for use in continuing education. Without evidence on the effectiveness of present teaching methods in non-credit courses, it cannot be determined if newer instructional aids contribute or fail to contribute to continuing education.[4] Benchmark studies should already be under way if evaluation of new instructional methods is to be available at the time they will be needed.

In at least this area -- research on education and specifically on continuing education activities -- universities and colleges are best equipped and qualified to take leadership in continuing education. Although interest in new methods is not confined to continuing education, these new methods are certainly germane to solving some of the distance, time, and cost problems connected with obtaining instruction from university faculty.[5] Pioneering the development, study, and evaluation of newer methods involving television and various other aids is a "natural" area in which universities and colleges can assume leadership.

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[4] A summary of new educational methods is given in Chemical and Engineering News, March 14, 1966, p. 19A.

A second important area in which universities can play a unique role is in setting the standards of quality for short intensive courses and for non-credit courses of longer duration. Traditionally, universities are expected to determine quality of education; they seem to be uniquely fitted to do this for the other sectors of society. The establishment of short intensive courses during the past few years as a popular mode of continuing education requires that this method be evaluated as to its effectiveness as a learning tool. What standards should be applied to continuing education is still an open question, although it is quite clear that, whatever they are to be, they will be different from those applied to student performance in credit courses in the regular university curricula.

In at least these two areas, universities and colleges should assume leadership. On the other hand, the universities do not now and should not be expected to supply all the effort in continuing education. Rather, continuing education in the sciences and engineering, and perhaps in all professions, should be a collaborative effort between universities training professionals, the societies which represent their interests, their employers, and the professional person himself. What university faculty can contribute to this collaborative effort is not only their knowledge and experience with teaching but also their knowledge and experience in experimenting with, studying, and evaluating the modes and methods of learning.

On the basis of the interviews with academicians, there is a trend to reduce and restrict off-campus offerings of both credit and non-credit courses. A corresponding shift to non-credit, on-campus activities has taken place among the "active" schools, and these activities need to be studied in terms of their contribution to learning and thus to the continuing education of professional persons. Research on the effectiveness of non-credit activities is necessary to evaluate them (see Chapter V) and also to determine the value of new instructional methods which are now being developed and considered for use in continuing education for scientists and engineers.

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[5] Only one of the 17 participating laboratories has actual experience with any of these newer methods, specifically tele-lecture and electro-writer. However, there is considerable awareness that these newer methods are being developed, and their potential is considered and evaluated from time to time by both laboratory managements and academic personnel interested in continuing education.

The shift from credit to non-credit in continuing education raises another question pertaining to evaluating the effectiveness of continuing education activities. For a variety of reasons, including the emphasis placed on advanced degree attainment by management and universities, many researchers are quite vocal in their desire to receive credit for continuing education activities other than regular university credit courses. This has raised the question of "professional credits" in some segments of the engineering profession; we are not aware of this issue being raised by the scientific societies.

To date, no universal system of professional credits has been developed and adopted. Several problems are involved in establishing such a system: it requires personnel, and it requires establishing and applying standards for certification, both of which are costly investments. It also requires agreement among the engineering and scientific societies on what standards should be applied and how they should be applied. No such agreement has been reached. Another hazard in the establishment of systems of professional credits is the impetus it inevitably will give to the accumulation of such credits for their own sake without regard to their relevance to an individual's work. This could be detrimental rather than helpful to the over-all problem of maintaining and upgrading the quality of the professional work force. Furthermore, there is no feasible way of incorporating the kind of intangible benefits obtained from reading, attending meetings, and the other interaction modes for which a professional credit system is inappropriate. Yet these modes may be more important for a significant segment of R&D professionals than course work modes, for which credits might possibly be developed. This issue is raised here to round out the discussion of credit versus non-credit, but no resolution of these problems is offered.

Defining Needs to Be Met

Our interviews with both management and academic representatives point up a failure to distinguish the need for advanced degrees from the refresher, upgrading, and diversification objectives of continuing education. In the past, university credit courses have been relied upon to satisfy both sets of objectives. Yet clearly there is agreement that university credit courses are only one mode and that others are also necessary to provide an adequate range of opportunities in continuing education for professional engineers and scientists.

Distinguishing degree-seeking from continuing education objectives is essential to clarifying needs in continuing education. In the interviews, when this distinction was made, both employers and academicians say that the most obvious alternative to the credit course is some form of non-credit activity which is more adapted to continuing education needs. The short intensive course, the non-credit course of longer duration offered evenings and weekends, or spending one day a week or one weekend a month on campus for intensive training are all formats which are now being used.

There are two other issues behind the definition of needs: one is the matter of released time and the other is that of establishing collaborative arrangements between the laboratory and the university. The latter is discussed in the following section.

Academic people imply or state outright that employers are not prepared to support people in continuing education on released time. For example:

> We started a program in one laboratory and at the end of one year the students requested to come to campus to take courses during one afternoon and evening. They received a week's instruction in one day. That operated quite effectively. It was abandoned because the company policy with respect to released time and tuition refunds was modified.
>
> Dean, School of Engineering, Private University

In general, released time is not the preferred management solution to continuing education needs in these 17 laboratories because of loss of productive work time. On the other hand, employers do not regard sitting in the library, reading at the bench, and a certain amount of time in discussions with colleagues as "released time." By released time is generally meant some hours off the job, away from work, spent in study at a university on a recurring basis, one day a week or so.

Academic people claim that *if* they are to upgrade and expand their activities in continuing education, employers will have to make more time available to the employees who are to benefit. Further, the more intensive the continuing education experience is to be, the more continuous the time that will have to be given over to it, whether for updating or diversification. Thus, this issue underlies some of the problems of defining and meeting needs. Wherever there are extensive programs of continuing education in the 17 laboratories, participating employees use at least some of the employer's time, whether this is considered to be "released time" or not. *Therefore, the issue is more precisely stated that an increase in university-laboratory collaborative efforts in continuing education will require an increase in released time of employees from work activities*.

Collaborative Arrangements

Most of the collaborative arrangements between specific universities and any of the 17 laboratories deal with arrangements for degree-seeking programs or for-credit courses (either on-site or on-campus) leading to a degree. These agreements take the form of reduced-time programs of one kind or another in which employees may seek advanced degrees largely at the employer's expense and partly on work time. Thus, most collaborative arrangements are not specifically for continuing education.

Collaborative arrangements on continuing education activities tend to be of short duration, sporadic, and are often designed to fulfill a specific need. Among these laboratories, there are only a few instances in which a university and a laboratory management specifically collaborate on long-range planning over a period of years for continuing education for employees in the laboratory However, there is great potential for collaborative efforts. At least in the 12 "active" schools, and we suspect in some of the "inactive" ones as well, there is a willingness to consider undertaking collaborative long-term efforts, although it is not clear just what direction these should take. The following types of interrelationship are already in existence:

1. There is a mutual effort to keep each other informed, not only about developments in knowledge but also in order to develop and maintain "good" relations with each other. For example:

> Beyond our regular training for degrees in which we collaborate with several government agencies, we try to stimulate interaction through our seminars. This is a flow between the university and the laboratories. Everyone is on everyone else's mailing list. We are trying to establish the tradition that we are happy to be the home of the government scientist on sabbatical.
>
> Department Chairman, Physics, State University

2. There is an exchange of personnel already going on which is informal, but which is recognized as of mutual benefit. This takes the form of consulting, thesis supervision, in-lab teaching (as a consultant), part-time teaching in the university, and simply conversations and collaborations on problems of mutual research interest. For example:

> Our faculty have friends in the laboratories around here and know their ability and their equipment. There may be a great deal of interaction between them without any formal agreement. It's simply a matter of doing it.
>
> Dean, Graduate School, State University

Sometimes these arrangements are formalized, as in the "coupling" arrangements between certain universities and several of the government laboratories in the sample. These "coupling" arrangements are simply memoranda of understanding that the two institutions (the university and the laboratory) agree to collaborate, but they do not specifically state what form or content is involved in the collaboration. It is, however, a commitment to each other to work together. One chairman said of it:

> I am not sure just how it is going to work out. The memo of agreement is going to ease things a bit. I think we will have difficulty getting our faculty to enter these laboratories on a regular basis. We are considering television. We have talked about an experimental program: offer a course, videotape it, and then present it in-lab. I can see a beautiful situation of a library of lectures on tape, and the student can go through the lecture again and again. We have an outstanding man here in these educational techniques.
>
> Department Chairman, Mechanical Engineering, Private University

3. In certain instances, there are collaborative arrangements which have benefited the university involved in quite specific ways. As a result of such arrangements, a general attitude of cooperation has evolved:

> There is no doubt that we have benefited from [the laboratory nearby]. They have done everything in God's world to help us. We have been able to hire faculty and to use their laboratory resources. This has helped us to build up our school. For this reason we try to contribute back and forth.
>
> Dean, School of Engineering, State University

And, from the same university:

> We are doing special things together with [the laboratory]....It's a tremendously important thing to be in a position to do this kind of thing for people in the technical fields....The advantages to the university are tremendous. In some of the departments that fit into this program, we are not terribly well covered in areas of specialization that more and more have to be covered in order to teach students. We are a small school. We feel [the laboratory] has specialists we are lacking and, therefore, we can avail ourselves of the opportunity to tap the talents of these people.
>
> Dean, Graduate School, State University

The use of laboratory-owned facilities and equipment is often an advantage to university faculty who lack them on their own premises. This advantage mainly occurs where there is access to equipment and facilities which are unique and relatively very expensive.

These types of interrelationship between universities and laboratories are an important adjunct to continuing education efforts, since they produce the spirit and attitude of cooperation which makes specific continuing education activities easier to establish. On the basis of what the academic people say about the various modes they have experimented with, four conditions exist which are necessary to obtain their interest and cooperation in collaborative arrangements of a formal kind:

1. Adequate financing, generally by the employer. Alternate sources of financing are tuition fees by individual participants and money from private foundations and the Federal Government agencies. Continuing education activities must be fully supported, not subsidized by the university.

2. Academic merit, which means that the continuing education activity involves a learning experience which faculty regard as

worthwhile to the student and which results in benefits to his employer through his increased competence on the job.

3. Mutual benefit, that is, the university faculty must regard the continuing education activity as consistent with their image as educators and as providing some kind of feedback and teaching experience of benefit to them as teachers. They must also have the freedom to prepare and present themselves and their material in a way consistent with their standards and values.

4. Adequate staffing with persons who, in the opinion of the university faculty, are qualified to teach continuing education courses. However, these persons need not all be university-connected people, providing academic credit is not involved.

The issue of financing received considerable comment in our interviews. Briefly, money from employers for continuing education is regarded as "soft" money in that no long-range commitment is usually made to the university and it can be, as one dean said, "turned on and off like a faucet." Academic administrators are very conscious of this fact because it prevents them from making long-range commitments to faculty in order to handle continuing education. They do not and cannot hire and lay off faculty on a short-term basis; therefore, if sufficient faculty are to be hired so that faculty time can be devoted to continuing education, money must be available on a continuing basis, not just for one semester or one year. (One reason why short intensive courses are so popular with both universities and employers is that no long-range commitment is involved. The registration fees are high enough so that, without regard to charged-off overhead, these courses appear to pay for themselves. It is not so clear that other formats are as self-supporting.)

While these conditions can be specified as necessary, they may not be sufficient to involve a university faculty in continuing education activities. Some faculties (and therefore some universities) have decided to concentrate their efforts solely on training students seeking degrees and doing research. However important the problems of continuing education may be, these schools are not prepared to deal with them. This raises the question of which schools should be actively engaged in continuing education and what should the scope of their efforts be? The "Goals" Committee report (p. 23) points to the great diversity of degree educational programs; should we expect an equal diversity in continuing education programs? It seems unreasonable to expect that each major university will become involved in continuing education to the same extent or cover the same scope of methods and content. Rather, diversity in two directions should be encouraged: (1) in programs designed to serve a general segment of the scientific and engineering population, such as short courses; and (2) in specific collaborative arrangements between individual laboratories and universities, such as the coupling arrangements described above. It is in the latter type of arrangement that these two institutions can develop the kind of mutual effort which will assist employers in developing long-range plans and commitments to continuing education and which will provide universities with some of the resources they need to make participation in such programs possible and worthwhile.

Summary and Conclusions

On the basis of the interviews with academicians, two general approaches to continuing education, "active" and "inactive," are distinguished among the 24 schools. We have tried to present as fairly as possible the arguments and logic which stand behind each of these approaches, as well as to describe as precisely as we can the patterns or uniformities in the activities described to us by representatives of the "active" schools. In addition, this chapter has attempted to summarize the status of current efforts to define the role of the universities in continuing education. This effort is very dynamic and the definition of what universities should be doing is very much a topic of current consideration among the academic people interviewed. Presumably, changes and new developments will evolve out of these deliberations.

In our opinion, one of the most basic changes which will have to take place before continuing education will get the emphasis, effort, and energy which is needed from universities is to incorporate into the university reward system acknowledgement that continuing education is a respectable and reputable career line for academic faculty. At present, the interviews with academicians imply an underlying assumption that such activities are somehow second-rate and do not merit, or at least do not receive, the same rewards of prestige and promotion which accrue to faculty who do research, publish, and teach degree-seeking students. In other words, the place of continuing education in academic efforts at present is contingent on individual faculty members sacrificing the rewards of the academic system or squeezing continuing education efforts into the myriad of other activities demanded of them. This is one side of the coin.

The other is the general down-grading of non-credit activities in the spectrum of university teaching relative to courses in the regular curricula. Yet there is general agreement that continuing education must be non-credit (for the most part) in order to develop formats which are more flexible than university credit courses in meeting individual's needs.

We are not in a position to suggest a resolution of this problem, but it should be squarely faced without rationalizing it away into the background. Otherwise, it crops up in every effort to initiate and establish the kinds of collaborative arrangement between laboratories and universities which are so fruitful and productive of interchange between the two. Not only does research benefit from collaborative arrangements (witness the large amount of consulting done by university faculty which is credited with keeping them in touch with the practice of their professions and with giving the laboratory the benefit of their expertise), but continuing education also benefits and, in turn, can be mutually rewarding to both the university and the laboratory as illustrated in the quotations and analyses of this chapter.

We have made several specific recommendations in this chapter:

Further research is needed on what standards should be applied to non-credit course work modes of continuing education along with investigation of the amount and quality of learning actually taking place in these modes. This recommendation has double force since it stems from the data presented in this chapter and is also made on the basis of other data presented in Chapter V. Universities seem best equipped to undertake this kind of research in collaboration with employers.

Universities and colleges should accept leadership in developing, evaluating, and experimenting with, new methods of instruction in order to explore their potential usefulness in the field of continuing education.

Employers must be prepared to increase the amount of released time of employees to engage in continuing education in order to take advantage of appropriate modes of continuing education which are available only or primarily at times other than evenings and weekends. In the opinion of some experienced academicians, effective new options in continuing education may require one day a week, one weekend a month, or other time periods away from work at a university. While released time is a matter of employer policy, its relevance to university efforts is such that without it universities are effectively stymied in experimenting with varying-size blocks of time.

Diversity in continuing education efforts on the part of the schools should be encouraged and supported in two directions -- programming activities for the population of scientists and engineers, and developing collaborative relationships with specific laboratories which mutually benefit the school and laboratory as organizations. Special emphasis is placed on the need for long-range planning for continuing education in these collaborative arrangements because there are few instances of it among the sample of 17 laboratories, although the "coupling" arrangement is a beginning. Also stressed is the need for long-range financial support of universities by employers and others if universities are to more heavily commit themselves to continuing education programming.

In general, these recommendations tend to expand and intensify presently existing efforts is continuing education. We also recommend, as others have done, that the search for new and different educational techniques and modes be continued in order to maximize the alternatives available to scientists and engineers, both in R&D and in other functions.

CHAPTER X

SUMMARY AND RECOMMENDATIONS

Throughout the study there is a clear-cut distinction between seeking an advanced degree and upgrading from activities more generally regarded as purely continuing education, that is refresher, updating, and diversification activities. The objectives of the latter are to maintain the individual's competence in the fields of knowledge and technology pertaining to his present work or work he anticipates in the near future. Continuing education thus has a pragmatic and practical orientation -- to help an individual in his career, to maintain his level of competence so that he can sustain or improve his level of skill and productivity.

Introduction

As viewed by R&D scientists and engineers, continuing education is a dynamic process, one which is heavily influenced by the phenomenon of technological obsolescence but not necessarily a result of it. These research-oriented people do not view technological obsolescence, at least for themselves, as an all-or-none proposition. Researchers can readily conceive of themselves or their colleagues as being deficient in some new area or in some developments in their field or tools. But they do not see themselves or their colleagues in research as "obsolescent" or "not obsolescent." Rather, their view of the matter is more dynamic. Continuing education is a process of keeping up to date, thus preventing obsolescence, rather than one of overcoming obsolescence. The former, keeping up to date, is viewed as a positive and continuous activity, a natural and inevitable part of the career and work life. The latter, overcoming obsolescence, is a remedial process, one which does not apply to a research person in toto because, if it did, he could not continue working in research. Indeed, the relativity of the concept of technological obsolescence is demonstrated by the fact that people engage in a range of activities all at the same time, some of which are refresher, some updating, some diversification, and some strictly for keeping up to date with the state of the art. Engaging in one type of activity does not preclude engaging in any of the others at the same time.

Two critical points emerge from an examination of the literature on continuing education. The first is that there is a scarcity of information -- to say nothing of systematic data -- on scientists except for that generated by the American Chemical Society, which is notable for its pioneering efforts in providing continuing education opportunities to chemists. The second is that there are few systematic studies of any kind based on direct observations of the continuing education process -- neither by employers, who pay most of the bills, nor by universities or professional societies, which sponsor many of the activities.

The literature includes statements suggesting that employers are concerned with the costs of programs and with the direct benefits to participating individuals and their laboratories. The employer view is highly economic and "production" oriented. This point of view is the generally accepted basis for management thinking and is credited with the success of the American management process. That it should be applied to continuing education as well is to be expected. On the other hand, there is a highly "moral" flavor to many of the statements concerning continuing education made by employer representatives as well as by those representing other points of view. In general, this "moral" flavor is one of not wasting the highly-developed and finely-honed talents of professional persons by neglecting opportunities to maintain their competence in the face of developing technology. For both the employers and the professionals whom they employ, pressure of time, especially time taken away from productive work, is always a difficulty no matter how the process of continuing education is approached.

The purpose of this study is to collect and interpret facts relating to the need for, the use and appraisal of, continuing education by research and development scientists and engineers in large industrial and government organizations. The principal findings are summarized below.

Summary of Study Findings

There are three key points in top laboratory management's philosophy of continuing education. Top management accepts the responsibility to provide at least some opportunities for scientists and engineers in the R&D work force. Top management expects R&D employees to take advantage of these and other opportunities to keep themselves up to date, particularly in their own fields of specialization. And, finally, top management accepts only limited responsibility for motivating the individual. Motivation is delegated to lower levels of management and supervision, or the initiative is entirely left to the individual.

The picture is simplified by identifying three broad approaches to continuing education:

1. Interaction modes of continuing education, such as attending professional meetings, in-lab lectures, and seminars, and going on sabbatical leaves.
2. Subsidized outside course work, such as university credit courses, short intensive courses, or longer non-credit courses meeting periodically over a span of weeks.
3. In-lab educational activities, such as laboratory-taught non-credit courses, journal clubs, and grass roots seminars.

Employer programs of continuing education consist essentially of various combinations of six different modes of continuing education. On the whole, most managements make use of three modes: university credit courses for which tuition is refunded; attendance at professional meetings for which expenses are paid (and time off is given); and regular series of in-lab lectures and seminars. There is greater variation from laboratory to laboratory in sponsorship of the other three modes: in-lab, non-credit courses taught by laboratory personnel; outside short intensive courses; and sabbatical leaves with pay. There is also a library in each of the 17 laboratories which is an important resource both in its housing of the literature and in its provision of services to researchers.

In addition to these six employer-sponsored modes of continuing education, there are three self-teaching modes: reading the scientific and technical literature, journal clubs and grass roots seminars, and teaching.

It is not typical in any of these 17 laboratories for management to make systematic efforts to evaluate its continuing education programs or activities.

Not only is there little or none of the research characteristic of other types of personnel training, but there are no systematic records of costs maintained to evaluate benefits in relation to expenditures. This is surprising in view of the considerable expenditure for continuing education in most of these laboratories. For five of them from which we could collect comparable data, the average is just under $600,000 annually.

As already noted, R&D scientists and engineers see continuing education as a complex and dynamic process oriented toward positive goals and functions. Generally speaking, these goals are:

> 1. Keeping up to date with the state of the art in their own field or fields of work in which they expect to be competent, particularly the state of the art as practiced in R&D laboratories as compared with universities.
>
> 2. Keeping up to date with allied and adjacent fields which impinge on, or relate to, their own fields of competence or which bear directly on their work activities.
>
> 3. Acquiring whatever knowledge they need in order to continue working in their fields of specialization or assignment; whether this is new knowledge or not is irrelevant to the need for it; pertinence is what matters.

R&D scientists and engineers are aware of the need for highly specific, detailed depth study of their own field above and beyond their current assignment as well as of the need to maintain some breadth of understanding of developments in the wider discipline or disciplines which comprise the more general boundaries of their competence and interest. In short, they are oriented to catching up, if needed, and to a continuous process of keeping up to date and acquiring additional competence as required by the job.

In general, more scientists than engineers engage in each of the continuing education activities involving contacts and interaction with colleagues inside and outside the laboratory, although approximately half the engineers also engage in each of these interaction activities. (Specifically, these activities are attending professional meetings and in-lab lectures and seminars, and going on sabbatical leaves.) Scientists are also more active in journal clubs, grass roots seminars, and teaching -- all of which are self-teaching modes of continuing education. Engineers in general are not active in these latter modes in the 17 laboratories studied.

Scientists also tend to be more active in continuing education in general; that is, there is a tendency for scientists to use more of the available modes than engineers, although over half the engineers are equally as active as scientists. Thus, the differences observed between R&D scientists and engineers are tendencies which are accounted for by the fact that heavily development-oriented people (which includes more engineers than scientists in the sample) are less active both in the interaction modes of continuing education and in general. In this sample, the more research-oriented people are the more active in the modes of continuing education examined.

On the other hand, almost no differences between scientists and engineers are found in the number of hours spent reading the scientific and technical literature, a self-teaching mode which both scientists and engineers agree is the most important activity in keeping themselves up to date. However, the data also suggest that, on the average, scientists spend more time reading journals and texts than magazines; and that engineers spend more time reading trade and technical magazines than academic journals.

Based on a correlation analysis of questionnaire responses, the scientists with Ph. D. s and masters' are those who emphasize the interaction modes in their continuing education activities. These people tend to work in small groups as independent researchers or else they supervise large groups of other people. They also report a high level of publications and autonomy in directing their own work.

Those who take subsidized outside course work -- either regular university courses or short intensive courses -- tend to be people with bachelors' and masters' degrees, who are less well paid than those described just above, and who report little autonomy or independence in setting their own research goals. Those taking credit courses are generally younger men who report a relatively low degree of satisfaction with their present work. This implies these men are seeking to achieve a better position in research through further education, but they are not necessarily seeking advanced degrees. By contrast, those taking non-credit courses -- usually short intensive courses -- are not necessarily young, and they rank this mode as more important to them than other modes (except reading). This suggests that these people have more restricted and short-range goals in continuing education than others do.

Those people who engage primarily in in-lab, non-credit course work tend to be young, without Ph.D.s, and to have received few promotions. They are also heavy readers and users of the library. These people report only modest contributions from themselves to the literature, to the employer organization, and to science in general. This suggests they are very "organization oriented" and without much contact with the wider world of science and engineering outside the laboratory.

This research examined each of the nine modes of continuing education in detail drawing on both interview and questionnaire responses. In general, the analyses suggest that university credit courses are best suited for in-depth learning of the fundamentals of a subject. R&D personnel who want to have a thorough grounding in a subject take university credit courses for this purpose. They are primarily used among members of this sample for diversification, that is, to learn the fundamentals of a subject not previously studied. They are only rarely used for refresher purposes; that is, seldom does a researcher take, once again, a course he has previously taken.

In-lab, non-credit courses sponsored and taught by employers may also be used for learning the fundamentals of a subject -- they may serve this purpose, but our R&D scientists and engineers say they themselves do not learn as much in such courses as they learn in university credit courses. Whether or not "as much" is desirable or not depends almost entirely upon what is needed by the individual student. The high level of student performance in university credit courses may not be necessary for the purposes of many individuals in R&D. Many individuals may very well learn all they really need to know to enhance job competence in less demanding courses. However, it is later recommended that quality of student performance in non-credit activities be a topic of future research.

On the other hand, among the course work modes, in-lab, non-credit courses seem uniquely best suited to serve the refresher and updating needs of R&D personnel. While mathematics is one area singled out for special mention, in-lab, non-credit courses can be used to refresh and update personnel in any subject matter area useful to, and needed by, laboratory personnel. A special use of such courses is to prepare scientists and engineers to take university credit courses for which they do not have the prerequisites. No other existing mode of continuing education seems as well suited for refreshing and updating as in-lab, non-credit courses.

Outside, short intensive courses are especially valuable to those whose job demands and other commitments do not permit attendance at courses stretched out over longer periods of time. Such courses are also valuable to those desiring quick, but not necessarily deep, understanding of a subject matter area. Partly because of their "away-from-the-job" feature and partly because of their convenience, short intensive courses have considerable potential for continuing education. The main drawback of such courses is that people find it difficult to maintain a high rate of absorption of the material studied over a one- or two-week period.

Two of the three interaction modes -- professional meetings and in-lab lectures and seminars -- have the distinctive function of helping people keep up to date with the state of the art in their own fields of work. These two modes are unlike course work in that neither is particularly well suited for the person who is already out of date and behind the times. To make best use of attendance at professional meetings and in-lab lectures, an individual must not be obsolescent in the topics discussed or presented, because the presentation assumes a current knowledge of the context to which it relates. This is especially the case for short papers presented at professional society meetings and for in-lab lectures.

Sabbatical leaves also help people keep up to date, but they do much more. Sabbaticals are taken for the purpose of getting caught up in great depth in areas in which the individual is already working, or for the purpose of pursuing a new or related line of research by studying with a senior colleague in another laboratory or university. In either case, there is no sharp break with the individual's past but a diversification as well as updating related to prior research and training. Sabbaticals result in revitalization and reorientation of the individual; the result is very much a recharging of the individual's potential.

Reading is regarded as the most important mode in keeping up to date. In spite of the fact that there is a widespread feeling and belief that it is impossible to keep up with the volume of current scientific and technical literature because of lack of time, the average number of hours spent in reading work-related literature is about ten per week with an additional nine spent in reading non-work-related literature. And, in spite of the fact that research people need familiarity with a broad base of current knowledge, they inevitably narrow the scope of their reading to bring it to bear on the job and utilize whatever short-cuts to the literature are available -- abstracts, indexes, retrieval systems, and the like.

Journal clubs, grass roots seminars, and teaching all appear to have great potential for continuing education. The journal clubs are primarily for covering the literature and the grass roots seminars for discussing research problems. Both are voluntary organizations composed -- in this sample -- mostly of scientists. Teaching is also a voluntary activity initiated through the individual's own efforts. All three of these types of activity seem to be under-exploited as modes of continuing education at the present time.

There are clear differences among supervisors in the manner and degree to which they stimulate and attempt to motivate their subordinates to engage in continuing education. Three types or styles of supervision are identified:

> 1. The "Administrator" is seriously concerned with implementing management policy, including policy concerned with continuing education, and tries to arouse the interest of subordinates in whatever employer-sponsored activities are provided.
>
> 2. The "Innovator" is vividly aware of the potency of new knowledge and of continuing education and regards these activities as central to his supervision of others. He is alert to opportunities to create continuing education activities in addition to pushing those sponsored by management. He is sensitive to the continuing education needs of his people and keenly perceptive of the resources available in the wider community, both those which do and those which do not fit these needs.
>
> 3. The "Inactive" type of supervisor is basically passive and noncommittal in his attitudes. He conceives of self-development and continuing education as a responsibility of the employee apart from the working environment. He neither stimulates subordinates to pursue continuing education nor initiates activities on their behalf.

In short, the kind of supervisor an individual is will make a difference in the energy and enthusiasm for continuing education among his subordinates.

Supervisors faced with a problem of an unmotivated individual attempt to deal with him in one or more of three ways:

1. By changing his environment in such a way as to provide stress through new and diverse work situations which force him to cope with problems he has not met before.

2. By pressuring the individual either with threats of removal or by stressing potential rewards of salary, job-related prestige, and professional status.

3. By no longer trying to motivate him, either by removing him from the work group (by transfer or firing) or making him so uncomfortable he removes himself.

From the subordinates' point of view, 61 percent of the scientists and 49 percent of the engineers report that their supervisor stimulates and assists them in keeping up to date. About one-third of the scientists and just under half of the engineers say their supervisor takes a noncommittal point of view toward continuing education; only a few report active discouragement by their supervisor. Those who report that their supervisor is noncommittal give as an explanation of his attitude his concern with the loss of their productive work time.

With reference to employer policy, over one-third of the scientists and one-fourth of the engineers say it has strongly encouraged them in their continuing education. Just under one-fourth of the scientists and over one-third of the engineers say employer policy has had no effect on their continuing education. The remainder say it has partially influenced them. The men who cite employer policy as positive -- either strongly or partially encouraging them -- cite specific assistances they have received: tuition refunds, opportunities to attend short courses, meetings, the chance to pursue reading on the job, and the like. They perceive employer policy as having benefits for them but benefits that are not explicit goads so much as instruments facilitating their study and learning objectives.

Employer policy, unless it is implemented in a very active and energetic way -- comparable to what "Innovator" supervisors do -- is likely to be regarded as somewhat ancillary to the man's desire (or disinclination) for continuing education. He sees employer policy positively when it facilitates his efforts, but a substantial number of men are exposed to an attitude on the part of "higher ups" which focuses on their economic value in ongoing work and which clearly sees continuing education activities as all too readily infringing on the employer's prerogative of demanding time and energy for the enhancement of production.

The findings summarized above represent the principal focus of our investigation. In addition to investigating the matters of employer policy, employee participation, supervisory influence, and the specifics of the modes of continuing education, 71 academicians in 24 schools located near the 17 laboratories were interviewed. In general, the academic point of view is that their primary task is educating degree-seeking students and conducting research; continuing education is secondary to these goals. As represented in the interviews, most university faculties have general views and policies about engaging in continuing education. These views enable us to classify 12 of the schools as "active" and 12 as "inactive" in continuing education. By "active" is meant some university sponsorship of continuing education activities beyond permitting non-degree students to enroll in university credit courses, such activities as short intensive courses, special lectures, seminars, and other non-credit participation specifically for the continuing education objectives of refreshing, updating, diversification, or keeping up to date.

The "inactive" universities and colleges believe they cannot do more than they do because their resources are limited or they denigrate continuing education as a legitimate preoccupation of the university. In the "active" schools continuing education is regarded as intimately related to the broad goals of a university, and these schools engage in specific activities, often experimental, to improve the continuing education services they provide.

Both "active" and "inactive" schools report considerable frustration and disappointment in past experience with off-campus teaching either for credit or non-credit. As a result, these schools tend to concentrate whatever they do on the campus and to have continuing education activities be non-credit. This permits an avoidance of all issues relating to dilution of the degree-seeking programs of the school.

Universities and employers also experience frustration in developing collaborative efforts in continuing education because of differences in point of view over selecting students and because the kinds, quality, and intensity of continuing education efforts are not agreed upon. In addition, the academic setting does not offer incentives and rewards to faculty members devoting major time to continuing education to the same extent that it rewards the primary functions of teaching and research.

In evaluating both curricula and student performance, the academic world is accustomed to using as a criterion of its activities the relevance of study for a professional degree. Since this criterion often does not apply in continuing education, difficulties of understanding are frequently experienced on both the employer and the university side. Most of the collaborative programs between the 17 laboratories and the universities pertain to degree-seeking programs in which mutual understanding is usually experienced because both sides have the same expectations of these programs. This is not so for continuing education activities.

In general, universities regard four conditions as essential to developing collaborative continuing education efforts with employers. These are:

1. Adequate financing, generally by the employer, but possibly also from tuition, foundations, and government agencies.
2. Academic merit, involving a learning experience which faculty regard as worthwhile for the student and which results in benefits to his employer through his increased competence on the job.
3. Mutual benefit to the faculty by being an experience consistent with their image as educators, by providing them with a worthwhile experience; they must also have the freedom to prepare and present themselves and their material in a way consistent with their standards and values.
4. Adequate staffing with persons who, in the opinion of the university faculty, are qualified to teach continuing education courses, but these people need not all be university-connected people, providing credit is not involved.

While these four conditions are necessary, they may not be sufficient to involve a university faculty in continuing education activities.

For whatever reasons, some universities have decided to concentrate their efforts solely on training students seeking degrees and doing research. However important the problems of continuing education may be, these schools are not prepared to deal with them. This raises the question of which schools should be actively engaged in continuing education and what should the scope of their efforts be? This study does not deal with this question directly. Hopefully, there will be an increase in the kinds of collaborative effort which will assist employers in developing long-range plans and commitments to continuing education and which will provide universities with some of the resources they need to make participation in such programs possible and worthwhile.

Discussion

Among the 17 laboratories, continuing education programs are much more like each other in lab after lab than is implied in the existing literature. At the same time, the modes of continuing education are not highly structured. For example, reading the literature is a very important and prominent mode and clearly one that is voluntary and personally-organized (or disorganized). Reading is also an activity which continues under conditions of repeated and often intense competition with other activities in a professional's life, including other modes of continuing education. Even employer-sponsored programs of in-lab, non-credit courses are not highly structured -- standards of student performance are not uniformly applied, usually anyone may register, and there is little or no integration or coordination of these courses so as to systematically cover some area of knowledge or to achieve some specific updating goal. With university credit courses and outside, short intensive courses, the course itself is highly structured and organized, but the process by which the individual selects and undertakes one or another course is less than orderly, often unplanned, and at times slipshod.

Concomitantly, most laboratories have either no, or markedly inadequate, records of continuing education among their employees -- employer-sponsored modes fare little better than personally-organized and self-teaching modes. Further, most laboratories have no consistent budgeting or coördination of their continuing education, and none, in the study sample, systematically evaluates the results, either short-term or long-range.

In trying to analyze and consider continuing education as a total field, the complexities are no fewer. The most stable elements in continuing education are the individuals to whom it is addressed, that is, scientists and engineers "at the bench" and its relevance for their ongoing or directly anticipated work. But an examination of these working men in the area of their continuing education is impeded by the triple institutional grids which must be comprehended and penetrated by observers such as ourselves. There are the economic (employer-employee) relationship, the academic relationship, and the technological-scientific relationship.

Each of these interposes, so to speak, a grid between the professional man and those of us who observe him. Each area is a highly developed and substantially autonomous institution in our society, having not only considerable integrity and fullness in itself, but also providing its own rationales as to the benefits, contributions, methods of acquisition, goals, and even ethics appropriate to an individual who comes into its domain.

The academicians, for example, find their roots in the university, which typically brings up the professional's "disciplined study," "prerequisites," official credit, and so on. For the university, continuing education is a sideline demanding entirely too many waivers of traditional academic goals, prerogatives, expectations, and routines.

On the other hand, the laboratory managers take their ethos from the economic-industrial identification of technical work, including such concepts as "obsolescence" and the expectation that a person, like a machine, should produce a designated product at a predictable pace and in an established pattern. The benefits of education are traditionally defined by economics as most profitable to the individual. Hence, there is a strong underlying assumption that continuing education activities sponsored by employers are really rewards (even if sometimes given in advance like a "Go Now-Pay Later" travel plan). It then comes out, as so often with rewards in this world, that those who gather in most of them are least in need. But management cannot see (very often) the point of sending a shy and non-verbal young engineer off to the heady socializing of a national convention at company expense.

Finally, the professionals themselves regard the production of knowledge as the ultimate goal of their training along with a broad and widely accepted trend to regard technology as a moving and growing phenomenon which one "must keep up with" at any cost. Doing so is thus part of the identification of the self as a professional worthy to be regarded by colleagues as a peer and commanding, if not deference, at least respect from non-professionals.

All three of these institutionalized patterns overlay the individual and his continuing education activities like multiple sets of authority, each serving to protect and enhance some part of his technical know-how, each demanding he subscribe to its set of values and behaviors. Thus the individual -- to whom continuing education is ultimately addressed -- must meld these diverse opportunities and demands into the one set of activities best suited for himself at any given moment in time. His over-all career goals -- at whatever level he sets them -- will be influential in determining which combination of elements he puts together to achieve that somewhat nebulous and undefined condition of being up to date with the state of the art in his discipline and fields of work.

These three institutionalized patterns are not only a problem for observers like ourselves. Those who plan and provide continuing education activities are also unclear about, and face difficulties in resolving, which set of institutionalized demands and values have which logical implications for whatever activities they plan. In short, the priorities which will most benefit the individual have yet to be worked out among those who are sponsors of continuing education -- the employers, universities, and professional societies.

We suspect, too, that there are some fundamental differences between engineers and scientists which are relevant in defining needs. As persons, engineers may be more self-sufficient, more product-oriented (i.e., to tangible results of work and to tangible rewards, such as pay), and less dependent on intellectualizing and on colleagues for intellectual exchanges. By contrast, the subculture of the Ph.D.s in both science and engineering makes reading a "natural" kind of activity, reinforces experimental attitudes and behaviors, creates a strong interest in theory and principles, and, in general, creates stronger notions of professionalism than the general subculture of engineers. In science, the traditions of professionalism are older than in engineering, more generally accepted and oriented to the rewards of esteem from one's colleagues, and tending to relegate to second place the pragmatic uses of knowledge and the tangible rewards of pay and administrative success. Impeding the development of a similar tradition in engineering is the contrary tradition, already established and expected of engineers, of moving into management, of becoming controllers of administrative processes and men as a natural outgrowth of their skills as controllers of technological processes and things.

As to what level of participation should be expected of each individual professional scientist and engineer, there is undoubtedly a wide range of effort within which individuals can remain adequately up to date in their own work and in allied fields which pertain to it. On the basis of the figures on participation presented in this report, the scientist or engineer who makes a serious effort to prevent obsolescence must anticipate devoting, on the average, ten hours per week in work-related reading and from 40 to 80 hours per year in some combination of other modes of continuing education. This is the best estimate available of what experienced practitioners working on the frontiers of knowledge are now doing. This amount of effort on the part of individuals who are now minimally engaged in continuing education will keep them up to par with senior and productive people in research. It could also set a benchmark or standard for management to use in determining whether personnel are making appropriate efforts and in evaluating their own support of various modes. Like all benchmarks, this one must be used flexibly, not as an arbitrary measure; otherwise another rigidity is introduced into a system which depends for its success on its adaptability to the widely varying needs of specific individuals.

Finally, we are not overly impressed with the amount and nature of the planning done by individuals for their own continuing education. We sense a fair amount of "hit-or-miss" activity, especially in choosing professional meetings, short courses, and to some extent in reviewing the literature. That is, what planning takes place is usually short-term without regard to the long-run future. While we recognize that no one can know the future, many of the developments now taking place will unquestionably adversely affect the future careers of those who ignore them. As an example, we point to the inadequacy of many people in dealing with computers whose potential they should have recognized a decade ago as being of relevance to sophisticated research techniques. For many, it is now too late, and there is increasing dependence on "computer experts" on the part of senior people who failed to understand and prepare to use this potential.

In spite of the difficulties inherent in long-run planning for continuing education, individual scientists and engineers should at least annually make some kind of systematic review of their needs and devise plans for meeting them either through self-teaching or through other available opportunities.

Summary of Recommendations

This section recapitulates the recommendations scattered throughout this report although appearing mainly at the conclusion of each of Chapters III through IX. The recommendations are reorganized here and grouped under subsections pertaining to action by management, professional societies, and universities.

Management. It is a matter of self-interest for management to know more about the continuing education process taking place among its professional employees who are supported in large part through significant employer expenditures. At least three steps must be taken in order to evaluate employer-sponsored continuing education programs.

1. Managements should institute an accurate record-keeping system which will reflect not only the numbers and types of personnel engaged in any one of the employer-sponsored modes of continuing education but also the cost per participant. This is basic information for the following recommendations.

2. Management should take additional steps to measure and assess the modes in terms of their value to the laboratory and the individual. Without such basic personnel research as characterizes other types of employer-sponsored training, management is not able to effectively assess whether continuing education pays off.

3. Management should investigate the priorities which should be established for their particular professional work force and determine which of the alternative modes should be supported and to what extent. This requires a sophisticated degree of understanding of the continuing education process.

4. In connection with the above, management should also study the area of intertwining between advanced-degree programs and the more purely continuing education modes. We have alluded (in Chapter III) to some of the problems inherent in the sponsorship of both when management fails to distinguish (for employees) who is expected to participate in what. The impact of advanced-degree programs on continuing education activities when both are sponsored in the same

work environment is at present an unknown quantity.

The following recommendations all pertain to one or another kind of course work; these are presented from a management point of view, but we do not intend that other sponsors should shy away from undertaking similar evaluations.

5. Ways need to be found to overcome the physical and psychological barriers to taking university credit courses. Alternative forms of transportation might be used to overcome the driving and parking-time problem faced by so many individuals living in congested urban centers. The scheduling of university-sponsored and other courses should take these practical problems into account.

6. Management should periodically and systematically evaluate the need for course work among its R&D scientists and engineers. This review should cover course work available in the community and the ease of access to it, needs for refresher and updating course work sponsored and taught by laboratory staff, and needs for advanced course work in specialized subjects not available in the community in the fields and disciplines of the R&D effort. If necessary, refresher and updating in-lab, non-credit course work should be planned and integrated into a sequence or series to permit comprehensive coverage of a discipline or subject-matter area.

Mathematics and mathematical subjects are especially singled out as an area for intensive planning and remedial instruction, since so many of the men interviewed talk about mathematics as a deficiency in their understanding of course work and in reading the mathematically-based literature. But other subject-matter areas should also be reviewed.

7. Student performance in non-credit activities should be scrutinized further in future research in order to insure that adequate learning is taking place. At present, in both in-lab, non-credit courses and outside, short intensive (non-credit) courses, there is little or no systematic evaluation of how much or what the students are learning, let alone the value of this learning to the individual's work. Such evaluation is as much management's task as it is one for other

sponsors of non-credit activities (universities, professional societies, and independent sponsors).

8. Student-employee participation in non-credit activities should be dependent on the professional's willingness to meet the standards of required performance set by the instructors in these courses, and they should not be permitted to adopt a laissez-faire or passive attitude toward homework or other assignments basic to the educational process.

9. Management should also set up some central place in the organization where information on outside, short intensive courses is collected and made available to those considering, or in need of, such course work. As it is, the information now seeps through to the scientists and engineers through a variety of channels, thus increasing the difficulties of knowing about, and selecting, the appropriate short course.

This research shows the value of interaction with colleagues in keeping up to date. Five specific objectives of interaction are identified in Chapter VI, and the interviews indicate that all of them are important to research personnel.

10. Therefore, management and others interested in furthering continuing education should provide these forms of interaction with colleagues to R&D people at all levels as a source of information and stimulation. Professional societies, universities, and colleges can also play a strong part in providing these opportunities. An important related question is whether or not junior-level personnel should be supported to a greater extent than they now are in attending professional meetings. The data presented suggest that their opportunities are more limited than those of senior researchers but that they might benefit tremendously from such exposure.

With reference to the self-teaching modes of continuing education, two specific recommendations are made to management:

11. Management should continue to seek ways of helping scientists and engineers cope with the literature explosion. Several specific techniques already in use in some of the laboratories studied are described at the end of Chapter VII.

12. Management should exercise more initiative in fostering journal clubs and grass roots seminars for those R&D employees who find this a familiar and useful way of covering part of the literature and of familiarizing themselves with the work of their colleagues. This mode of continuing education needs further study to determine the range and scope of its contribution, especially for scientists, who seem, in this sample, more ready to adopt this type of activity than do engineers.

In all these efforts, management will need continuous feedback and appraisal from the professionals themselves. The following recommendation is made with this in mind:

13. Managements which do not have a professional development committee should establish one. The function of this committee is to initiate, review, and recommend action programs in continuing education (see Chapter III). A professional development committee can also suggest and recommend priorities among the evaluative efforts urged above; it can conduct and evaluate reviews of needs in the professional work force; and it can create and sustain enthusiasm for continuing education because its very existence demonstrates management's support of, and reliance on, continuing education as a professional development technique.

The final recommendation for management results from the analyses presented in Chapter VIII.

14. Management should make explicit that one of the functions of supervision in R&D is stimulating subordinates to continuing education and reviewing with them (at least annually) their plans for self-development. Conscious recognition of what the "Innovator" type of supervisor is and does will help make plain what management can demand and expect of supervision.

Professional Societies. While this research does not include a specific effort to examine the role and activities of professional societies, several recommendations are made on the basis of the data pertaining to activities sponsored by these societies.

1. Professional societies should establish and periodically publish a central-clearinghouse type of listing of continuing education activities such as meetings, short courses, and the like. It seems to us that this is a natural function of a professional society. Excellent examples can be found in Chemical and Engineering News published by the American Chemical Society and in the American Dental Association's quarterly, Continuing Education, both of which are distributed to members on a regular basis.

2. Local chapters of professional societies which are not now active in continuing education should at least review their local circumstances to determine what, if anything, they could be doing. We are under the impression that in many of the communities we visited, the local chapters of both scientific and engineering societies either fulfill a primarily social function or are inactive. In Chapter I, we cited some of the efforts of the engineering societies to provide materials and guidelines to local chapters interested in starting continuing education activities.

3. Professional societies and other publishers of the scientific and technical literature should consider ways of increasing the number of review articles and papers. Apparently, there is much more emphasis placed on publication of original research findings than there is on the integration of these into coherent and comprehensive statements of emerging trends in theory and their implications over a broad range of topics. The interviews reveal an expressed need to correct this imbalance.

Universities. In Chapter IX, we distinguish "active" and "inactive" schools in continuing education. Among the "inactive" schools, some faculties avoid continuing education because they feel it will dilute their main efforts of teaching and research. Others avoid it because it is somehow not worthwhile to them. The former attitude is understandable and perhaps justifiable in light of limited resources and already heavy demands. The latter attitude, however, represents a failure to assume responsibility for prolonging and enhancing the productivity of the capital investment represented by a formal degree. The most general recommendation is that ways need to be found to make continuing education efforts worthwhile to university and college faculties which are not now active.

Traditionally, society looks to the universities to determine quality of education, since they seem to be uniquely fitted to do this. The following recommendations are made because of faculty expertise in studying the kinds of issues involved.

1. Universities, particularly those which are sponsors of continuing education activities, should also sponsor research in the following areas:

   (a) The amount and quality of learning in the various modes of continuing education, particularly non-credit course work modes,

   (b) The standards of learning which should be applied to student performance in non-credit course work,

   (c) The effectiveness of new instructional methods, such as television and other audio-visual systems with potential application to continuing education modes, as they are applied to scientists and engineers engaged in continuing education.

2. The reward system of the academic world should be enlarged to include appropriate recognition for efforts in teaching and researching continuing education courses and other relevant issues. The present system rewards teaching regular degree-seeking students and publishing research results; even faculty who might be interested in the field of continuing education may be discouraged from becoming active because of the lack of rewards. The data reveal that university faculty are the most frequent source of lecturers in the in-lab lecture and seminar series, as well as the most frequent source of consultants in these 17 laboratories. Thus, we cannot conclude that faculty time is so severely limited that continuing education efforts on campus in non-credit activities are impossible to fit into their schedules.

3. Concomitant with the above, universities should upgrade the status and prestige associated with teaching in non-credit continuing education activities; enlarging the reward system will be a step in this direction. As others have also recommended, continuing education

should become a third dimension along with teaching and rewards, of equal status and importance in over-all university efforts.

4. Diversity in continuing education efforts on the part of schools should be supported in two directions: on-campus programs for scientists and engineers and collaborative arrangements with employers which mutually benefit the school and laboratory as organizations. As part of this, employers will have to consider issues of released time and further long-range support of university efforts. Universities will have to face issues of increased faculty to supply high-quality manpower to continuing education activities, faculty who will not only teach but, in many instances, regard continuing education as a major thrust of their research efforts.

General Recommendations. First, in planning and carrying out this study, we encountered a need for consistency in language and definition. In order to simplify what is meant by continuing education, we adopted with minor revision the classification of activities presented by the "Goals" Committee. It is at least clear that upgrading (seeking a degree) should be distinguished from refreshing, updating, diversification, and maturing of a person's education and each of these distinguished from each other. Otherwise, "failures" of communication occur because people make erroneous assumptions about what another says or means.

Second, a need exists to make more explicit the theoretical or conceptual formulation of the boundaries of continuing education. There is a grey area between the objectives of continuing education and those activities which achieve these and those activities resulting from the intellectual curiosity which leads scientists and engineers into areas of study beyond job competence. Yet there is no reason to think that such curiosity is not equally worthy of encouragement and stimulation on the part of management.

Third, it is difficult to trace out the effects of participation in any one mode of continuing education on participation in others. For example, does attending professional society meetings actually stimulate people to undertake further reading and study of topics which caught their interest at the time of presentation in the meeting? And, if so, has this benefited them on the job, or in some other way, such as feeding their intellectual curiosity beyond the job areas? Allied to this is a need to know and understand the relation, if any, between the kind and quality of degree preparation and subsequent involvement in continuing education in later years. Presumably, if curricula have changed, later involvement in continuing education can also have changed. While we discard the notion of a half-life of formal education as too rigid and arbitrary a concept (implying, among other things, an inevitable decline into obsolescence, which we have seen can be prevented), it is hoped that the curricula of later years has better prepared professional people for a lifetime of learning. Yet we know of no ongoing investigations into this critical question. Hopefully, those interested in continuing education will not fall into the same trap of assuming the relationship exists and will take care of itself, as has been done with the critical question of motivation.

Finally, there is a need to know much more about the processes by which universities and employers enter into, and maintain, successful collaborative arrangements for continuing education, as well as for other activities of relevance to science and engineering manpower.

APPENDICES

APPENDIX A

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APPENDIX B

COOPERATING LABORATORIES AND SCHOOLS

The following laboratories, universities and colleges participated in this study. Social Research, Inc. and the principal investigators wish to join with the National Science Foundation in expressing our deep appreciation of the time and assistance given to us by these organizations and the various members of their staffs. The contribution of their personnel to this study is manifest throughout this report.

LABORATORIES

Industry

The Dow Chemical Company
Midland, Michigan

Lockheed Research Laboratories
Lockheed Aircraft Corporation
Palo Alto, California

Western Development Laboratories
Philco-Ford Corporation
Palo Alto, California

Polaroid Corporation
Cambridge, Massachusetts

Sandia Laboratory
Albuquerque, New Mexico

Xerox Corporation
Rochester, New York

Anonymous (3)

Government

Air Force Cambridge Research Laboratories
Bedford, Massachusetts

National Aeronautics and Space Administration
Manned Spacecraft Center
Houston, Texas

National Institutes of Health
Bethesda, Maryland

Naval Research Laboratory
U. S. Department of the Navy
Washington, D. C.

Naval Ship Research and Development Center
U. S. Department of the Navy
Washington, D. C.

Northern Utilization Research
and Development Division
Agricultural Research Service
U. S. Department of Agriculture
Peoria, Illinois

U. S. Army Ballistics Research Laboratories
Aberdeen Proving Ground
Aberdeen, Maryland

U. S. Army Natick Laboratories
Natick, Massachusetts

UNIVERSITIES AND COLLEGES

Boston University
Boston, Massachusetts

University of California
Berkeley, California

Catholic University of America
Washington, D. C.

University of Chicago
Chicago, Illinois

Columbia University
New York, New York

George Washington University
Washington, D. C.

Harvard University
Cambridge, Massachusetts

University of Houston
Houston, Texas

Illinois Institute of Technology
Chicago, Illinois

Lowell Institute of Technology
Lowell, Massachusetts

University of Maryland
College Park, Maryland

Massachusetts Institute of Technology
Cambridge, Massachusetts

University of New Mexico
Albuquerque, New Mexico

New York University
New York, New York

Northeastern University
Boston, Massachusetts

Northwestern University
Evanston, Illinois

Polytechnic Institute of Brooklyn
Brooklyn, New York

Rice University
Houston, Texas

University of Rochester
Rochester, New York

Rochester Institute of Technology
Rochester, New York

San Jose State College
San Jose, California

University of Santa Clara
Santa Clara, California

Stanford University
Stanford, California

University of Wisconsin
Madison, Wisconsin

APPENDIX C

DESCRIPTION OF STUDY

Pretest

During the planning stages of the study, information was developed on 35 laboratories, gathered from a variety of published sources as well as by word of mouth. Two laboratories not included in the final study sample were included in preliminary visits. These visits consisted of interviews with ten top executives about continuing education and its implementation in the laboratory. This experience helped us to formulate the plans for the initial pilot study described below.

Pilot Study

In the first of the laboratories included in the study sample of 17, the principal issues of the study were discussed with top laboratory management executives and with personnel and training executives. Data on employer policy and practices were also collected. A final interview guide for interviews with executives was designed on the basis of this experience.

Twenty scientists and engineers were also interviewed in this laboratory, using a preliminary form of the "Scientist/Engineer/Supervisor" guide. On the basis of these interviews, the final form of this guide was developed. This final form was used in the remaining nine laboratories in which interviewing was done.

On the basis of the interviews with executives and with the scientists and engineers, the Continuing Education Questionnaire was designed. This is primarily a structured questionnaire, on which the respondents check one of several provided answers. In addition, there are some questions to be answered in their own words. The Continuing Education Questionnaire was designed to be used in each of nine laboratories in which interviews were also to be obtained.

The Remaining Field Work

In addition to the pilot study laboratory, 16 other laboratories also participated in the study. In all laboratories, top management as well as personnel and training executives were interviewed. In nine of these laboratories, about 20 scientists and engineers were interviewed and about 45 additional personnel completed the Continuing Education Questionnaire. Thus, the intensive study of what scientists and engineers do is based on data from these nine laboratories plus the pilot study laboratory. A total of 205 scientists were interviewed face to face. A total of 411 completed the questionnaire; 394 of these were complete enough to be usable in the statistical analyses of this study. Table C-1 summarizes the number and types of people participating in each step of the study.

The questionnaire was administered in each of the laboratories by one of the principal investigators, who explained the purpose of the study and the hoped-for results to groups of scientists and engineers who had been selected to participate. (See Chapter II for how the selection was made.)

The questionnaire and the interview guide for scientists and engineers contain a number of identical structured questions. However, in the face-to-face interviews, there was typically not enough time to ask all of the structured questions, since most interviewed persons were more eager to discuss their activities in their own words. A time restriction of one hour had been placed on the interviews. Consequently, the time allotted was first devoted to exploring the details of the individual's activities and motivations in his own words. If there was time remaining, then the structured questions were asked. Typically, no such time remained. Therefore, in reporting the results of this study, the quantitative data are limited to the 394 individuals who completed the questionnaire. The two sets of data -- from the interviews and the questionnaire -- reinforce and enrich each other. Both have been used in the analyses presented in the text.

The remainder of this Appendix is devoted to describing the laboratories and the scientists and engineers who participated in the study.

TABLE C-1

NUMBER AND TYPES OF PEOPLE IN STUDY

TYPE	Subtotal	Total
Pretest Interviews		10
Management		
Top Laboratory	33	
Personnel and Training	36	
Other Managers	9	
Library Directors	17	
Total		95
Academic Personnel		
Vice Presidents	3	
Deans and Associate Deans	26	
Department Chairmen	19	
Heads of Extension, Evening, and Other Continuing Education Units	14	
Directors of Centers for Continuing Education	4	
Other Faculty	5	
Total		71
R&D Scientists and Engineers		
Interviews	205	
Questionnaire	394	
Total		599
TOTAL		775

The Laboratories

Nine industrial and eight government laboratories participated in the study. These laboratories are highly placed in their respective employer organizations and are not subordinate to other organizational units. All are physically separated from other components of the organizations, and 12 are on site, at a distance from other units of the employer organization. In addition, most of these laboratories are administratively independent; the chief technical director is on a level with other top corporate or government agency personnel, or, in the case of a few, he reports only to a higher level of R&D administration. For the most part, the organizational structures are shallow; there are only two or three levels of organization between the research scientist and engineer and the heads of major units or the top technical directors. Only the very large laboratories are exceptions to this.

These 17 laboratories may be described in terms of their long-run research efforts. Three of the government laboratories are engaged in non-military research, five are oriented primarily to military requirements and needs. Three of the industrial laboratories are engaged almost entirely in research under contract to the Federal Government; three are oriented to their own operations and products; and the remaining three are oriented to the public or other industrial organizations as consumers of products.

A precise classification of the research efforts of these laboratories would be arbitrary, since, in all, there is a mixed spectrum of activities and directions in research. Pharmaceuticals, cereals, oilseeds and other crops, space medicine and physiology represent only some of the fields of life science in which these laboratories are engaged. Others are concerned with missiles, space vehicles, tracking and telemetering, and instrumentation, all of which are representative of the most advanced work in the space sciences and engineering. The latest breakthroughs in mathematics, chemistry, and physics are incorporated into their efforts. In many of these laboratories, there is also research in progress within the many specializations of the engineering disciplines. In some laboratories, there are also pilot plants and experimental machine shops employing a variety of skilled personnel, including additional scientists and engineers not engaged in research. The fact that in over two-thirds of the laboratories 50 percent of the professionals are scientists testifies to the research emphasis of the population studied.

Tables C-2 through C-4 describe some of the more salient features of the 17 laboratories. These tables do not describe industry and government laboratories separately; the data have been examined for differences between industry and government, and those which were found are presented in the main body of the report.

TABLE C-2

DISTRIBUTION OF 17 LABORATORIES BY NUMBER OF R&D PROFESSIONALS EMPLOYED

PROFESSIONALS EMPLOYED	N Labs
250 - 499	3
500 - 999	7
1,000 - 1,999	4
2,000 - 2,500 Plus	3
TOTAL	17

TABLE C-3

R&D SCIENTISTS AS PERCENT OF TOTAL R&D PROFESSIONALS EMPLOYED

PERCENT SCIENTISTS	N Labs
Less than 25 Percent	-
25 - 49 Percent	4
50 - 74 Percent	6
75 or More Percent	7
TOTAL	17

TABLE C-4

GEOGRAPHIC LOCATION OF PARTICIPATING LABORATORIES

LOCATION	N Labs
Massachusetts	3
New York - New Jersey	3
Washington - Maryland	4
Michigan - Illinois	3
Texas - New Mexico	2
California	2
TOTAL	17

Scientists and Engineers

In both the interviews and the questionnaires, information was obtained on personal history, job history, and other background characteristics. This information is summarized in Tables C-5 through C-11. The 205 people interviewed have been combined with the 394 people answering the questionnaire, because there are no essential differences on these characteristics between the two samples.

Tables C-5 through C-7 describe the personal background of these 599 scientists and engineers. The median age is 36; 93 percent are between the ages of 26 and 55. In Table C-6, the term "doctors" includes Ph. D. s, who form the majority of this group, as well as M. D. s. Other doctorates in veterinary medicine, a few advanced degrees of "engineer," and a sprinkling of other advanced degrees beyond the master's represent a very small number of people. There are seven men who report no degree information; these are tabulated with the bachelors'.

TABLE C-5

AGE

AGE	N	Percent
21 - 25	27	4
26 - 30	114	19
31 - 35	155	26
36 - 40	105	18
41 - 45	96	16
46 - 50	48	8
51 - 55	27	4
56 or Over	16	3
No Response	11	2
TOTAL	599	100

TABLE C-6

EDUCATION

EDUCATION	N	Percent
Highest Degree Held		
Bachelor's	207	35
Master's	169	28
Doctor's	208	35
No Degree	7	1
No Response	8	1
TOTAL	599	100
Currently Completing		
Master's (technical)	49	8
Master's (non-tech)	9	2
Doctor's	40	7
Not Currently Seeking a Degree	501	83
TOTAL	599	100

The two largest scientific specialties reported in Table C-7 are the physicists and chemists. Together they make up 40 percent of the total. The biological scientists appear underrepresented (reported as one percent). This is because many of those trained in one of the biological sciences have also received interdisciplinary training in chemistry, physics, or one of the branches of engineering. These people typically classify themselves by the non-biological term or as "other" in the table. Among the laboratories which employ these 599 people are two with a high concentration of life scientists. These two laboratories were selected in part to make sure that biological scientists were included in this study.

The two largest groups of engineers are electrical and "other." In the "other" category are most of the newer branches of engineering, although the various electronic and aeronautical specializations make up a large part of this "other" category.

TABLE C-7

DISCIPLINE

DISCIPLINE	N	Percent
Scientists		
Physicists	134	22
Mathematicians	23	4
Chemists	112	19
Biological*	6	1
Other	82	14
Subtotal Scientists	357	60
Engineers		
Electrical	78	13
Mechanical	53	9
Chemical	24	4
Materials Science	10	1
Civil	4	1
Other**	73	12
Subtotal Engineers	242	40
TOTAL	599	100

*Biochemists and other bioscientists typically choose one of the other categories to designate themselves.

**Electronic and aeronautical engineers in various specializations make up a significant part of the 73 "Other" engineers.

Table C-8 describes the career history of these 599 scientists and engineers. Forty-three percent have held only one job, and 29 percent have held two jobs. Thus, 72 percent have had only one or two jobs in their careers, indicating a rather high degree of job stability among these research people. Since the age distribution of these people is fairly equal in five year breaks between ages 26 and 45, this stability is not attributable to a disproportionate number of younger or older people in the sample. This finding is at variance with the commonly held belief that there is considerable mobility from employer to employer among R&D personnel. (Number of jobs held includes only jobs held as professional persons; excluded are military service, teaching and other assistantships while seeking a degree, and any non-professional position.)

TABLE C-8

PROFESSIONAL PERSONNEL DESCRIBED BY CAREER HISTORY

NUMBER OF JOBS HELD	Percent N=599
1	43
2	29
3	17
4 or More	11
TOTAL	100

PROMOTIONS ON PRESENT JOB	Percent N=599
None	25
1	26
2	15
3	15
4	9
5 or More	10
TOTAL	100

PROFESSIONALS SUPERVISED NOW	Percent N=599
None	49
1 - 5	32
6 - 10	9
11 - 20	5
21 or Over	4
No Response	1
TOTAL	100

PRESENT SALARY (in thousands of dollars)	Percent N=599
9 or Less	9
10 - 11	25
12 - 13	25
14 - 15	20
16 - 17	10
18 - 19	4
20 or More	3
No Response	4
TOTAL	100

TABLE C-9

PROFESSIONAL MEETINGS: MEMBERSHIP AND ATTENDANCE

Number of Memberships Held in Professional Societies	Percent N=599
None	22
1	30
2	24
3	14
4	7
5 or More	3
TOTAL	100

Frequency of Attending Annual and Local Professional Meetings	Percent N=599
None	27
1	19
2	17
3	7
4	5
5	3
6	5
7	3
8	2
9 or More	8
No Response	4
TOTAL	100

TABLE C-10

PROFESSIONAL PRODUCTIVITY IN THE PAST FIVE YEARS

Productivity in Last Five Years: Number of Each	Patents** %	Technical Papers Published %	Technical Books Published %	Unpublished Reports %	Courses Taught %
1	16	16	4	15	12
2	7	9	1	12	7
3	4	9	*	9	3
4	2	5	-	6	1
5	3	8	-	8	2
6	1	3	-	4	1
7	*	2	-	2	*
8	1	2	-	2	*
9 or More	3	8	-	19	3
None	62	37	94	21	67
No Response	1	1	1	2	4
TOTAL (N=599)	100	100	100	100	100

*Less than 1 percent

**Includes patent applications

Table C-11 shows highest degree held by both age and type of employer. Slightly more of the younger men with masters' degrees are employed in industry than in government, and appreciably more of the younger doctors are employed in industry. Among the older men, again appreciably more of the doctors are employed in industry than in government.

TABLE C-11

COMPARISON OF HIGHEST DEGREE HELD BY AGE AND TYPE OF EMPLOYER

AGE AND EMPLOYER	Highest Degree: Bachelor's N=222 %	Master's N=169 %	Doctor's N=208 %
Age 35 or Younger			
Industry	26	30	32
Government	28	24	11
Subtotal Younger	54	54	43
Age 36 or Older			
Industry	22	23	34
Government	24	23	23
Subtotal Older	46	46	57
TOTAL	100	100	100

The distributions in Tables C-5 through C-11 are not to be extrapolated to industry/government differences or to any other large population. They are merely descriptive of this group of 599 scientists and engineers. This group is neither a random nor a representative sample of R&D scientists and engineers.

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